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Inspection/Maintenance Program Options for Iowa, Kansas, and Nebraska

Booz-Allen and Hamilton, Inc, Bethesda, MD

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16. ABSTRACT

This report presents an analysis of alternative motor vehicle emission inspection and maintenance programs for the following metropolitan areas: Davenport, Iowa; Des Moines, Iowa; Omaha, Nebraska-Council Bluffs, Iowa; Wichita, Kansas; and Johnson and Wyandotte Counties in Kansas (Kansas City area). The study methodology utilized is described. The study included collecting data, determining criteria for selecting alternative program configurations, screening program options, and evaluating alternative configurations selected through the screening process. Program alternatives were evaluated in terms of emissions reductions attainable, geographic coverage, effective motor vehicle population, inspection frequency, consumer protection, quality assurance, costs and financial feasibility. The ease of implementing different alternatives was also studied.

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INSPECTION/MAINTENANCE PROGRAM OPTIONS FOR IOWA, KANSAS AND NEBRASKA

Final Report

by

BOOZ·ALLEN & HAMILTON Inc.

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ABSTRACT

This report presents an evaluation of alternative motor vehicle emissions inspection/maintenance (I/M) programs to assist the States of Iowa, Kansas and Nebraska in choosing a preferred I/M program. This evaluation was conducted in two steps. First, a screening of a variety of I/M program options was conducted and five alternative programs were selected for further evaluation. These alternatives were:

- State-operated - idle mode test
  - loaded mode test
- Contractor-operated - idle mode test
  - loaded mode test
- Private garage-operated - idle mode test

These alternative programs were evaluated in detail against a set of criteria including cost, financial feasibility, ease of implementation, consumer protection, consumer convenience, and flexibility for future modifications.

No single alternative I/M program was found to be the best for all criteria. The final selection of the most preferred program will depend upon the relative importance of each of the evaluative criteria as chosen by decision-makers in each State. Preferred programs are indicated for each State assuming equal weight for all criteria.

The Executive Summary of this report is included in a separate volume.

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I. INTRODUCTION

The control of emissions from new motor vehicles and industrial sources has considerably improved the ambient air quality in many areas over the past several years. In many metropolitan areas, however, the health related ambient air quality standards as required by the Clean Air Act of 1970 have not yet been attained. The Clean Air Act Amendments of 1977 set December 31, 1982 as the new attainment date for these areas, with a possible extension of up to five years for attaining the ambient standards for two pollutants, ozone and carbon monoxide, provided that certain conditions are met by the States requesting the extension. One of the conditions includes requirements for the States to implement motor vehicle inspection/maintenance (I/M)* programs in specified non-attainment areas of the State. Since different types of I/M programs exist, a State must choose the program that best meets its needs. In order to assist the States of Iowa, Kansas, and Nebraska in selecting the most suitable I/M programs, should they be required to implement one, this report presents an evaluation of alternative I/M programs for these States. The following sections contain a discussion of the objectives and scope of this evaluation, the evaluation methodology, and the report organization.

1. STUDY OBJECTIVES

The objective of this study was to assist the States of Iowa, Kansas, and Nebraska in evaluating the various I/M program options. As mentioned above, these States are now in the process of determining whether an I/M program will be needed to meet the requirements of the Clean Air Act Amendments. Thus, to assist these States in selecting the most suitable I/M program, should one be needed, specific objectives of the study were:

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* For background information on motor vehicle inspection/maintenance programs, the reader is referred to: U. S. Environmental Protection Agency, "Information Document on Automobile Emission Inspection and Maintenance Programs" EPA-400/2-78-001, February, 1978.

- To determine the costs of developing, implementing and operating the various I/M program options in the non-attainment areas of each of the States
- To evaluate the financial feasibility, ease of implementation, consumer convenience, consumer protection and flexibility of each option for each State
- To compare each of the I/M program options with respect to the factors of cost, financial feasibility, ease of implementation, etc., and recommend the most suitable option for each State.

Hence, the objective of the study was not to determine the need for I/M in each of the States, but rather to compare the I/M options.

2. STUDY SCOPE

In accordance with the contracted scope of work, the study was limited to five metropolitan areas in the three States which have been designated as "non-attainment" areas for ozone and carbon monoxide. These areas are:

- Johnson and Wyandotte Counties in Kansas, which are part of the Kansas City Interstate Air Quality Control Region
- Sedgwick County, Kansas, which includes the City of Wichita
- Polk County, Iowa, which includes the City of Des Moines
- Scott County, Iowa, which includes the City of Davenport
- Douglas and Sarpy Counties in Nebraska, and Pottawattamie County in Iowa, which are part of the Omaha-Council Bluffs Interstate Air Quality Control Region.

A map showing these five areas is given in Figure 1.

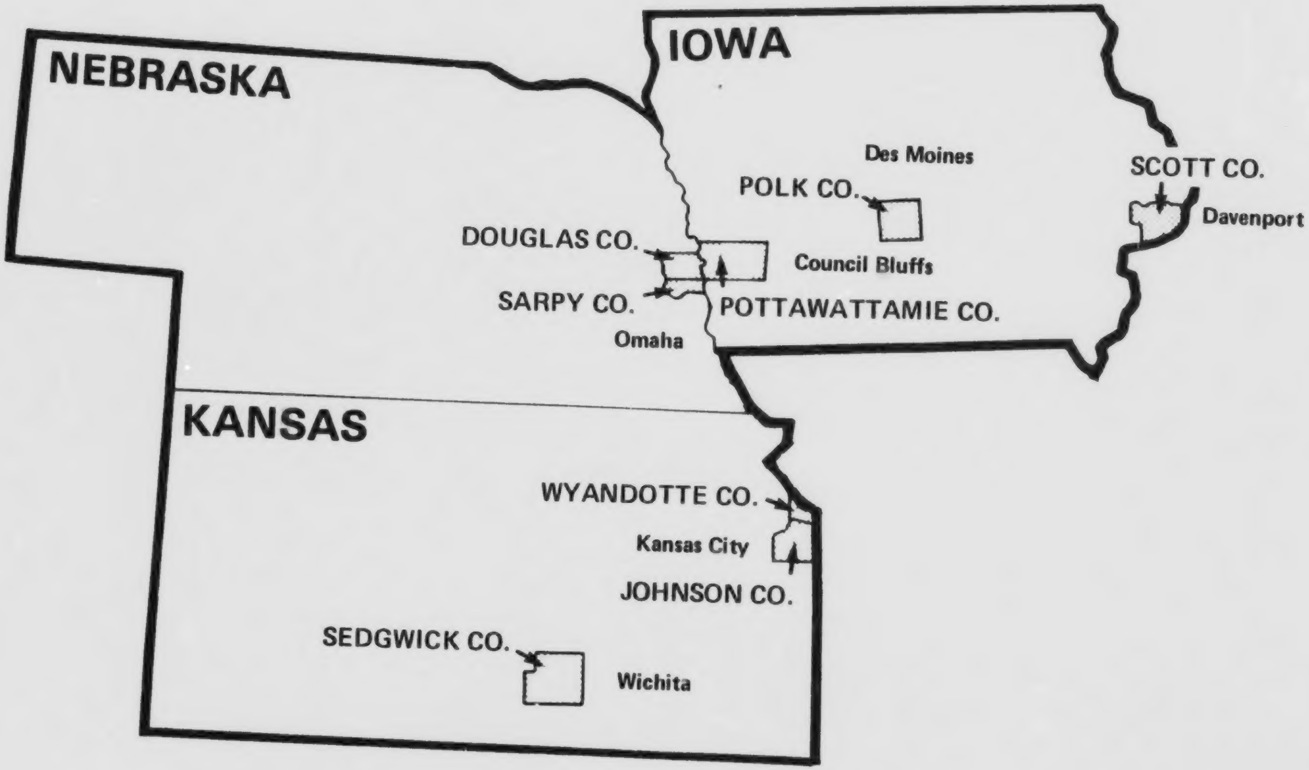
NEBRASKA
IOWA
KANSAS
Des Moines
POLK CO.
Council Bluffs
POTTAWATTAMIE CO.
SCOTT CO.
Davenport
DOUGLAS CO.
SARPY CO.
Omaha
WYANDOTTE CO.
Kansas City
JOHNSON CO.
SEDGWICK CO.
Wichita

FIGURE 1
Map of Study Areas

While the characteristics of each area were investigated in detail during the study, each I/M program was established on a State-by-State basis rather than on an individual study area basis. Thus, the three study areas in Iowa (Council Bluffs, Des Moines, and Davenport) were evaluated together, as were the two study areas in Kansas (Kansas City and Wichita). Omaha was the only area evaluated in Nebraska. This ensured consistency of program types within each State.

3. EVALUATION METHODOLOGY

Since an I/M program consists of a number of components or elements, each with multiple options, the evaluation of the I/M programs for the five study areas was conducted in two steps: preliminary evaluation of all program component options, and detailed evaluation of a selected set of I/M programs. Each is described below.

(1) Preliminary Evaluation

The preliminary evaluation was designed to identify the available options for each I/M program component and to eliminate from further consideration those that were clearly not feasible for the study areas. The preliminary evaluation was principally based on information available in the published literature on the existing I/M programs, with a minor emphasis placed on the information specific to each study area; however, close contact was maintained with respective State and local officials in carrying out this phase of the study. The output of the preliminary evaluation was a set of five I/M program options with each component defined for individual study areas.

(2) Detailed Evaluation

The I/M programs selected in the previous step were subjected to further evaluation for each study area. Each I/M program was first evaluated against cost and then against the following criteria:

- Financial feasibility
- Ease of implementation

- Flexibility for future modification
- Consumer convenience
- Consumer protection.

The alternative I/M programs were then compared and recommendations were made for selecting the most suitable I/M program for each study area. Regional information was used whenever available.

4. REPORT ORGANIZATION

The first five chapters of this report provide information common to all five of the study areas in the three States. The remaining three chapters provide a detailed evaluation of I/M programs specific to each State. The supporting data and equations for the detailed evaluations are included in the appendices.

II. NEED FOR AND BENEFITS OF INSPECTION/MAINTENANCE PROGRAMS

The need for a motor vehicle inspection/maintenance (I/M) program for emissions control can be considered from two viewpoints. First, it is mandated as a pollution control measure for certain areas in the nation by the Clean Air Act Amendments of 1977. Second, it can be considered on its own merits as an effective pollution control strategy because of the potential benefits resulting from the implementation of an I/M program. This chapter describes the requirements of the Clean Air Act Amendments and the benefits of an I/M program.

1. REQUIREMENTS OF THE CLEAN AIR ACT OF 1970 AND AMENDMENTS OF 1977

Under the authority and requirements of the Clean Air Act of 1970, national ambient air quality standards were established for six pollutants: carbon monoxide, nitrogen dioxide, non-methane hydrocarbons, ozone*, sulfur dioxide, and total suspended particulates. The 1970 Act required the U.S. Environmental Protection Agency (EPA) and the States to implement various pollution control measures to attain these standards nationwide by July 1, 1975. In spite of the implementation of the various control measures, many areas in the nation could not attain the national ambient air quality standards by this date. The Clean Air Act Amendments of 1977 extended the attainment date for the so-called non-attainment areas, but at the same time imposed stringent air pollution control requirements on the States. The Amendments also called for certain sanctions against the States if the requirements were not met.

The new deadline for the attainment of the health-related ambient air quality standards is December 31, 1982. However, if the States are not able to demonstrate the attainment of the standards for ozone and carbon monoxide by this date, the 1977 Act requires the States to establish a specific schedule for implementation of a vehicle

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* Also referred to as photochemical oxidants.

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emissions control inspection/maintenance program in the non-attainment areas. The general requirements for the I/M programs are described in the February 24, 1978 memorandum from the EPA Administrator to the Regional Administrators.[1] Another EPA memorandum on I/M policy dated July 17, 1978[2] provides details on the specific requirements for the I/M program implementation.

The principal I/M program requirements based on the 1977 Amendments and their interpretation in the EPA policy memoranda include the following:

- The States must revise the State Implementation Plan by January 1, 1979 to include a specific schedule for the implementation of an I/M program in the non-attainment areas
- The States must obtain adequate legal authority to implement the I/M program by June 30, 1979, or an extended date as provided in the EPA policy paper
- The States must implement the I/M program as expeditiously as practicable but no later than December 31, 1980 or 1982, depending upon the type of program and the date when legal authority is obtained.

A variety of sanctions are mandated by the 1977 Amendment against the States failing to meet these requirements. Thus, if a State failed to submit an adequate non-attainment area plan or failed to make a reasonable effort to submit an adequate plan, the EPA cannot approve projects or award grants authorized by the Clean Air Act. Similarly, the Department of Transportation cannot approve projects or award grants under Title 23 (which means the State stands to lose certain highway funds for the non-attainment areas). If the non-attainment plan did not meet the requirements of the 1977 Amendments, the State may not approve any major stationary sources in the non-attainment areas. This could restrict the growth of industries such as metal furniture manufacturing and paper and fabric coating, which produce significant quantities of hydrocarbons in the non-attainment areas. There are additional sanctions if the approved plan is not properly implemented by the State or other responsible agencies within the State.

Although the five study areas in Iowa, Kansas, and Nebraska have been designated as non-attainment areas for ozone and/or carbon monoxide, the States have not yet determined if an extension beyond 1982 would be needed to attain the applicable ambient standards in those areas. Should the States determine that an extension is needed, the above requirements must be met.

2. BENEFITS OF INSPECTION/MAINTENANCE PROGRAMS

The most important benefit of an I/M program is a reduction in the amount of air pollutants emitted in motor vehicle exhaust. Motor vehicles emit large amounts of carbon monoxide and hydrocarbons and typically represent the largest source of such emissions in an urban area. The hydrocarbons react with nitrogen oxides and other substances in the air in the presence of sunlight to form ozone, which is the principal constituent of smog. Although a precise relationship between the amount of hydrocarbon emissions and the ambient ozone level is yet to be developed, it is clear from the available data that the hydrocarbon emissions must be reduced to improve the ambient ozone levels. Thus, implementing an I/M program will reduce the motor vehicle emissions and help attain the ambient air quality standards for carbon monoxide and ozone. This means the public will be protected from the adverse health effects of these pollutants.* In addition to reducing the exhaust emissions, there may be secondary benefits from I/M programs in that improved vehicle maintenance provides the potential of improved fuel economy, increased performance, and longer vehicle life. The following paragraphs discuss emission reduction and vehicle operational benefits of I/M programs.

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* The ambient air quality standards promulgated by the EPA represent the maximum allowable pollutant concentration in the ambient air designed to protect the most susceptible segment of the population such as the elderly and the children from adverse health effects. These standards are based on laboratory and epidemiological studies and include an adequate margin of safety.

(1) Emission Reduction

Even though most vehicles must be capable of meeting emissions standards at the end of the assembly line, they eventually emit excessive amounts of pollutants because of emission deterioration. Emission deterioration results in an increase in vehicle emission rates as compared to average emission rates of new vehicles. Emission deterioration results from normal wear of engine and degradation of emission control components as well as changes in emissions due to tampering and inadequate maintenance. The purpose of an I/M program is to slow down the rate of emission deterioration by periodically inspecting and maintaining emission related vehicle components. Inspection identifies vehicle emissions problems by checking the emissions levels with respect to appropriate emissions standards for in-use vehicles. Then maintenance can be performed to ensure that the vehicles meet the standards when reinspected. Thus, the vehicle emission rate is reduced after the maintenance. The reduction in the emission rate of individual vehicles after maintenance primarily depends upon how much a particular vehicle deviated from the applicable emissions standard and how well the mechanic performed the required maintenance. The average reduction in the emissions from the vehicle population in an area after mandatory inspection and maintenance will depend upon a number of factors as discussed below:

- Stringency Factor - The stringency factor is the percentage of vehicles in an area that require emissions related maintenance to meet the standards set for the program. The stringency factor can be increased by making the emissions standards stricter, thus increasing the emissions reduction that can be obtained for the vehicles in the I/M program.

- Level of Mechanic Training - The effectiveness of an I/M program in reducing the emissions from in-use vehicles can be increased by training the mechanic to perform the required maintenance to meet the emissions standards. Since this is not a standard garage procedure, special training may be required.

- Vehicle Types - As the number of vehicles which are included in I/M programs increase, the effectiveness will increase. Many I/M programs only apply to light duty vehicles. Inclusion of light duty vehicles (passenger cars and small trucks), the principal contributors to the hydrocarbon and carbon monoxide emissions problem, may provide adequate vehicle emissions reduction in some areas. However, the effectiveness of the program can be increased by including large trucks and other heavy duty vehicles in the program.

- Years in Operation - The effectiveness of the I/M program is expected to increase with the number of years it is in operation.

- Frequency of Inspection - The effectiveness of an I/M program is expected to increase with more frequent inspection. Thus a semi-annual I/M program would be more effective in reducing emission than an annual I/M program.

Since the relationship between these factors and the effectiveness of the I/M program in reducing vehicle emissions is complex, the EPA has developed a simulation model based on empirical data to predict the effectiveness of an I/M program. This model is described in an EPA document called "Appendix N"[3] which is currently being updated. The estimated effectiveness of the I/M program based on the version of the simulation model as included in the EPA's MOBILE-1 computer program is presented in Chapters VI, VII, and VIII for each State. The final version of the model will appear in the revised Appendix N. At that time, an addendum will be prepared to this report incorporating the results of the updated model.

(2) Fuel Savings

Potential benefits of improved fuel economy may result from a well-maintained vehicle. However, the relationship between maintenance related to emissions reduction and improvement in fuel economy is not completely understood. Furthermore, available empirical data are not consistent. Some studies suggest substantial improvement in fuel economy as a result of an I/M program, whereas other studies indicate little or no effect of I/M on fuel economy. For example, an EPA study shows an average annual fuel savings of about 5.5 percent for serviced vehicles and about 1.65 percent for all vehicles under an I/M program operated with a 30 percent stringency factor.[4] The California Air Resources Board, on the other hand, found that with a 35 percent stringency factor, the fuel economy improvement is statistically insignificant when annual deterioration is taken into account, and the improvements is distributed over the total vehicle population.[5]

(3) Performance and Life

There may be some potential for the I/M program to provide a benefit in terms of vehicle performance and life. As far as performance is concerned, the impact of I/M programs will vary from one vehicle design to another. Indeed some vehicles for certain model years yield better "driveability" with selective degradation of emission control systems. In general, for later model cars it appears that I/M programs may provide better performances overall by assuring that vehicles are tuned to manufacturers specifications on a periodic basis. In addition, it might seem intuitive that the well-maintained vehicle will have a longer useful life. However, quantification of the performance and life concept is speculative at best. With recommended service intervals for modern vehicles being stretched to many thousands of miles and with the probability that in the next few years these service intervals will be increased, the performance and life benefit may not be measurable.

III. SCREENING OF PROGRAM OPTIONS

An I/M program is composed of a number of components including the type of program administration, emissions testing method, frequency of inspection, types of vehicles to be tested, stringency factor, enforcement mechanism, and geographic coverage. Since each program component has multiple options, an initial screening was conducted to reduce the possible I/M program options to those most appropriate for the detailed evaluation. Representatives from Kansas, Iowa, Nebraska, and the five metropolitan planning organizations of the study areas participated in this screening process. This chapter presents the methodology used in conducting the screening as well as the results of the screening process.

1. OVERVIEW OF APPROACH

An overview of the approach employed in the screening process is shown in Figure 2. As shown, the screening evaluation was conducted in three steps. Since the type of program administration and testing method are the two most important program components that characterize the operation of an I/M program, they were evaluated first followed by the screening of individual program components. The results of the three evaluations were then combined to formulate a set of five viable I/M program alternatives. The criteria used in conducting the three evaluations, the results obtained and the alternative I/M programs formulated for Iowa, Kansas and Nebraska are described in the following sections.

2. I/M ADMINISTRATIVE APPROACHES

Three administrative approaches have been demonstrated in existing I/M programs. These are:

- State-operated centralized programs in which the State owns or leases central inspection facilities and conducts the testing using State-employed inspectors

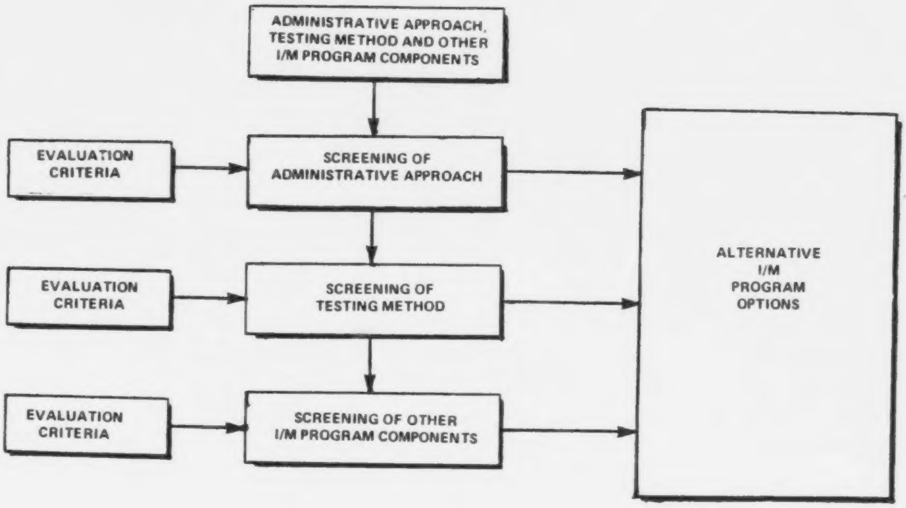
ADMINISTRATIVE APPROACH, TESTING METHOD AND OTHER I/M PROGRAM COMPONENTS
EVALUATION CRITERIA
SCREENING OF ADMINISTRATIVE APPROACH
EVALUATION CRITERIA
SCREENING OF TESTING METHOD
EVALUATION CRITERIA
SCREENING OF OTHER I/M PROGRAM COMPONENTS
ALTERNATIVE I/M PROGRAM OPTIONS

FIGURE 2
Overview of Screening Approach

- Contractor-operated centralized programs in which the contractor owns or leases central inspection facilities and conducts the testing
- Certified garage-operated decentralized programs in which a large number of private garages are certified by the State to conduct the testing.

The I/M programs in which these approaches are currently being utilized are shown in Table 1.

TABLE 1
Existing I/M Programs Categorized by Administrative Approach

Administrative Approach	Location of I/M Program	Year Program Was Initiated
State-Operated	New Jersey Oregon	1972 1974
Contractor-Operated	Arizona	1975
Private Garage-Operated	Rhode Island Nevada	1977 1974

A combination of the above approaches is also possible, but was not considered in this study because they represent "fine-tuning" of basic I/M systems that can be accomplished at a later date, if appropriate.*

(1) Criteria for Screening Administrative Approaches

The criteria used to screen the administrative approaches included financial feasibility, ease of implementation, consumer protection, and consumer convenience. Definitions of the criteria are provided in Table 2. The advantages and disadvantages of each administrative approach with respect to this criteria are presented in the next section.

(2) Results of the Screening

The results of the screening indicated that although each type of administrative approach has certain disadvantages, the advantages are sufficiently important to warrant a detailed evaluation. For example, while centralized programs require substantial capital investment, they provide uniform testing procedures and a check on the quality of repairs made

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*For example, in New Jersey initial inspections are conducted at State-owned and -operated facilities, while reinspections are performed, at the option of the motorist, at either the State facilities, or certified private garages.

TABLE 2
Criteria for Evaluation of Administrative Approach

Criteria	Definition
Financial Feasibility	Initial capital outlay required to implement program Ability of the organization to raise the capital outlay (State, private contractor, or private garage)
Ease of Implementation	Ease of acquiring the necessary land and buildings Amount of government hiring required Relationship with existing safety programs Compatibility with present management/institutional structures
Consumer Protection	Standardization of equipment calibration and vehicle testing procedures Consumer protection against faulty or ineffective repairs
Consumer Convenience	Traveling distance required for test and retest Waiting time required for testing

on the failed vehicles. The certified garage-operated program, on the other hand, provides maximum consumer convenience and requires less government capital outlay than that required by the State-operated centralized programs, but careful monitoring of the quality of the testing and repairs is required. Thus, all three administrative approaches were selected for further evaluation in the study. A summary of the screening of the three administrative options according to the four criteria is given below.

- Financial Feasibility. Centralized programs typically require high capital outlay for land, buildings, and equipment, which may present a problem in the case of a State-operated program as the government must raise the necessary funds. One advantage of the contractor centralized approach, however, is that it eliminates the necessity for a State government to make such large capital outlays for land and buildings. For example, in the program currently operating in Arizona and the proposed program in California, the investments for land, buildings, and test equipment were made by the contractor who, in turn, amortized these costs over the period of the contract. While the decentralized program, on the other hand, requires some capital investment by the State (i.e., construction of challenge garages only), for the most part, capital investment is made by private garages through the purchase of emission testing equipment in compliance with State specifications.

- Ease of Implementation. It is generally acknowledged that the bureaucratic procedures involved in the State land, building, equipment, and staffing acquisitions may slow implementation of an I/M program, and that very often a contractor can move more rapidly in these areas. This point was stated at the National Motor Vehicle Emissions Control Conference in April 1978.[6] In view of this fact, an administrative approach which reduces government acquisition of land and buildings could provide for a somewhat easier program implementation. Both the contractor and the certified garage approaches have this advantage. A certified garage program in an area which already has a safety inspection program offers additional advantages. In fact, both the EPA and the National Highway Traffic Safety Administration have recommended that a combined safety/emissions inspection would be cost effective and easy to implement.[7]

- Consumer Protection. Major considerations in providing protection to consumers in an I/M program include mechanic training, consistency in the test procedures, proper calibration of the emissions testing equipment, and a check on the effectiveness of vehicle repairs and maintenance performed in response to an emissions test failure. Protecting consumers through these and other techniques is easiest in a centralized program where there is a limited number of inspection facilities and the inspection and maintenance functions are separate. In a decentralized or certified garage program, the testing and calibration procedures and quality control may vary from one garage to the next and thus jeopardize the validity of the test results. Furthermore, special interest incentives may exist when a repair facility decides not only that a vehicle does not meet the emissions standards but also deter[illegible] the extent of the remedial repairs required.

- Consumer Convenience. The decentralized administrative approach has the advantage of offering inspection facilities at many locations throughout a non-attainment area, while the central locations of a State- or contractor-operated program may require motorists to travel five or more miles. The private garages also offer an opportunity for one-stop inspection, repair, and retest if required. Waiting time for all three approaches is a function of the time of day and the day of the month in which the vehicle is inspected.

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*EPA, however, has attempted to minimize these problems by defining certain consumer protection requirements for the decentralized I/M program, such as facility licensing and the operation of "referee" stations where vehicle owners may obtain an independent test to compare to a licensed station test.[8]

A detailed analysis of the three administrative approaches with respect to the above criteria is presented in Chapters V through VIII.

3. EMISSIONS TEST METHODS

The principal methods of testing for emissions in existing I/M programs are the idle mode and loaded mode tests. The idle mode test measures tailpipe emissions from a stationary vehicle at one or more engine speeds, while the loaded mode test measures tailpipe emissions under various engine loads using a dynamometer.* A loaded mode test is usually conducted at speeds of 50 mph, 30 mph, and idle. In addition to the idle and loaded test methods, some programs, such as Oregon, perform a tampering or underhood inspection of the vehicle emission control devices. This involves a visual inspection for the location and proper connection of the positive crankcase ventilation (PCV) system, the exhaust modifier system, the exhaust gas recirculation (EGR) system, and the evaporative control system. However, because such checks are time consuming and require substantial training of inspectors**, they are conducted by very few States with I/M programs. A summary of the test modes used in existing I/M programs is presented in Table 3.***

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* A dynamometer is a machine used to simulate the load an engine would experience when the vehicle is operated on the road.

** This is because different vehicles have different types and arrangements of pollution control equipment.

***Transient loaded mode tests such as the New Jersey/New York Composite test or the Federal Short Cycle test were not considered for this evaluation because they require a dynamometer capable of performing at variable inertia weights and road load settings and also because they demand a more controlled environment for testing than is available from a high throughput inspection facility.

TABLE 3
I/M Test Methods in Current Programs

I/M Test Method	I/M Program Location	Test Speeds
Idle	New Jersey	Idle
	Rhode Island	Idle
	Oregon	Idle and 2500 rpm
Loaded	Arizona	50 mph 30 mph Idle

(1) Criteria for Screening I/M Test Methods

The criteria used to evaluate the test methods included both cost and effectiveness. Cost is defined in terms of the testing equipment, the labor as a result of testing time, and the amount of inspector training required. Effectiveness is defined as the amount of expected pollution reduction obtainable as specified by the EPA. Significant issues in the evaluation of test methods were the cost of testing equipment, the length of time required to train inspectors in the test method and the amount of pollution reduction obtainable from each test method. Discussion of these issues is summarized in the next section.

(2) Results of the Screening

The results of the screening suggested that both the idle and loaded mode tests should be included in the study evaluation but that the underhood visual checks should be excluded. The idle mode test was selected because it is effective in identifying high emitters and requires inexpensive test equipment and minimum inspector training to perform the test. The loaded mode test, on the other hand, was selected because of its potential for providing detailed diagnostic information for repairs and for testing heavy duty vehicles if required; although this test requires costly test equipment which would not be practical for private garages. Since the visual inspection method does not meet the minimum EPA requirements for I/M programs, it was excluded from further evaluation as an independent test method. A summary of the results of the screening of I/M test methods with respect to the above criteria is provided below.

- Cost. The idle mode test and visual underhood check entail the least costs for equipment, while the loaded mode test requires equipment which is generally too costly for independent garages. An idle mode test requires use of an emissions analyzer which costs between $1,100 and $2,500 while a loaded mode test requires a dynamometer, in addition to the analyzer, adding $5,000 to $7,000 to the cost of the analyzer. A visual underhood inspection carries no equipment requirements. The cost of training inspectors is moderate for both the idle and loaded tests (a half day per inspector for idle tests, two to three days for loaded) but somewhat higher for a visual underhood check (five to seven days of training per inspector). These training costs continue throughout the program as new inspectors are hired. The cost to perform the inspection in terms of labor is greatest for a careful underhood check and least for an idle mode test.

- Effectiveness. An I/M program using either the idle or the loaded mode test is capable of achieving substantial reductions in vehicle emissions when used in conjunction with a reasonable stringency factor (the EPA has developed estimates of potential emissions reduction as a function of stringency factor).[9] There is, however, no evidence that a visual underhood check will provide a measurable reduction in pollution, or will meet the minimum I/M program requirements set by the EPA.

4. OTHER I/M PROGRAM COMPONENTS

In addition to the basic program types, decisions about several program components were necessary before the

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[*] EPA does not at this time have information that verifies that the more comprehensive loaded mode test yields greater emissions reductions than the idle mode test. The loaded mode test does, however, provide diagnostic information which is of greater value than that from an idle mode test.

detailed evaluation of alternative I/M programs could be performed. The next step in the screening process, therefore, was the selection of certain basic program components. Five components with well-defined variable options were discussed and evaluated by the representatives from Kansas, Iowa, Nebraska and the five local governments. These include inspection frequency, type of vehicles to be tested, stringency factor, enforcement procedure, and geographic coverage. Other I/M program components common to all approaches such as mechanic training and public information were included in the analysis but were not evaluated during the screening meeting. The available options for these components are not well-defined, and specialized expertise in training and public relations are required to determine the nature of these programs.

The basic program options included in the screening are discussed below.

(1) Inspection Frequency

Existing I/M programs have inspection frequencies ranging from change of ownership to annual inspection. An inspection required at the time vehicle ownership changes may be a good method of phasing into an I/M program. However, the inspection frequency dictated by a change in vehicle ownership inspection does not result in an adequate reduction of emissions. Similarly, biennial inspection, as practiced in Oregon, may contribute to reduction in pollution, but it is also not of sufficient frequency to meet the emissions reduction requirements for I/M as specified by EPA. The EPA thus has set annual inspections as the minimum requirement for I/M programs. For purposes of this study, this inspection frequency was accepted by the State and local planning representatives of the study areas.

(2) Type of Vehicles to be Tested

The choices presented for the type of vehicles to be tested are light duty (G.V.W. of less than 8500 pounds) and heavy duty (G.V.W. greater than 8500 pounds). As discussed in Chapter II, the inclusion of heavy duty vehicles in an I/M program provides additional emissions reduction as defined in Appendix N of the EPA regulations for administering the Clean Air Act. However, inspection of heavy duty vehicles carries additional cost considerations such as special tandem dynamometers, larger facilities, and exemptions of certain vehicles engaged in interstate commerce.

Since the amount of emissions reduction needed to attain the ambient air quality standards in the study areas was not yet determined by the States at the time of the study, the need for including heavy duty vehicles in the program was not known. Thus, only the inspection of light duty vehicles was considered. Light duty vehicles which were considered included passenger cars, light duty trucks and vans, and motorcycles.

(3) Stringency Factor

The stringency factor of an I/M program provides an indication of the rigor of the program by giving the percentage of vehicles tested which exceed the emission standards and are required to have remedial maintenance performed to reduce their emissions rate. This percentage rate is necessary in the cost analysis to determine the number of vehicles which must return to inspection station for a retest. This additional volume of cars through the system results in extra inspection time and demand on the facility and must be included in the cost calculations.

The appropriate way to determine the stringency factor for an I/M program is to measure the amount of pollution reduction that is needed to meet the air quality standards and match this requirement with the stringency factor which will provide the needed amount of reduction. EPA has defined the amount of emission reduction which can be expected from stringency factors of .10, .20, .30, .40 and .50.

Where the amount of pollution reduction necessary in a specific non-attainment area is not known, a stringency factor may be selected for planning purposes. In the case of Iowa, Kansas and Nebraska, the results of calculations to measure the existing pollution levels and the amount of reduction needed to meet the standards by December 31, 1982 were not avilable in time to calculate the costs of the alternative programs. Therefore, a .30 stringency factor was selected to provide an estimate of potential pollution reductions, based on the stringency factors being used by existing I/M programs in other states.

(4) Enforcement

The two methods being used by existing I/M programs for enforcement of the inspection and maintenance standards are either to combine the inspection as a mandatory prerequisite of the vehicle's registration or to enforce a separate sticker program by police citations. The ease with which the I/M program can be absorbed into the registration program depends on the structure of the registration program in each State.

In Kansas and Nebraska where staggered* registration procedures are used, it was assumed that the I/M programs under consideration would be combined with vehicle registration as an enforcement procedure. In Iowa, it was assumed that a separate sticker program would be evaluated because the registration in this State is not staggered.

(5) Geographic Coverage

I/M programs can be implemented on a statewide basis or restricted to a non-attainment urban region. The non-attainment areas in the States of Kansas, Iowa, and Nebraska are sufficiently small to make statewide programs unnecessary; thus, the programs were evaluated based on implementation in the non-attainment areas only.

5. FORMULATION OF ALTERNATIVE I/M PROGRAM OPTIONS

Based on the results of the above screening, the basic I/M program types included in the detailed evaluation were:

- State-operated facility with idle mode test
- State-operated facility with loaded mode test
- Contractor-operated facility with idle mode test
- Contractor-operated facility with loaded mode test
- Certified garage facility with idle mode test.

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*Distributed throughout the year.

The assumed characteristics of these programs were:

- Mandatory inspection of all light duty vehicles (LDVs)
- Annual inspection, evenly distributed over the year with a free reinspection for failed vehicles at the same station
- An initial inspection passing rate of 70 percent
- Inclusion of a training course for inspectors and mechanics to be run by the State
- Inclusion of a public information campaign to alert the public as to the new inspection requirement.
- Implementation of I/M in the non-attainment areas only
- Use of State owned and operated challenge garages and a State-run quality audit and enforcement program (garage operated program only).

The methodology for detailed evaluation of these five options is presented in the next section.

IV. METHODOLOGY FOR DETAILED EVALUATION OF I/M PROGRAMS

As was discussed in Chapter I, the I/M programs selected in the initial screening were subjected to further detailed evaluation for each study area. As shown in Figure 3, this detailed evaluation was conducted in three steps. The first step consisted of a detailed cost evaluation of each program alternative while the second step consisted of an evaluation of each alternative program against a set of institutional factors. The third step consisted of a cost effectiveness analysis based on emissions reduction estimates made for each of the study areas. The results of these three evaluations then formed the basis for an overall comparison of the alternative I/M programs. The methodologies employed for evaluating cost, institutional factors and cost effectiveness are described below. The results of these detailed evaluations are presented in Chapters V through VIII.

1. METHODOLOGY FOR ESTIMATING COSTS

The costs of an I/M program include capital investment, start-up, and operating costs. This is true regardless of the type of I/M program (i.e., State-operated, contractor-operated or garage-operated); although the costs can vary significantly by type. A summary of the major components of capital investment, start-up, and operating costs is as follows:

- Capital Investment Costs. These include all land, building and equipment costs incurred during start-up and throughout the life of the program.
- Start-Up Costs. These are costs other than capital costs, which are incurred before the program is operational. They include costs to design the program, to develop advance public information material and to conduct preliminary inspector/mechanic training.
- Operating Costs. These are costs associated with the day-to-day operation of the program, such as labor, public information, mechanic/inspector training, utilities and supplies, and maintenance and repair costs.

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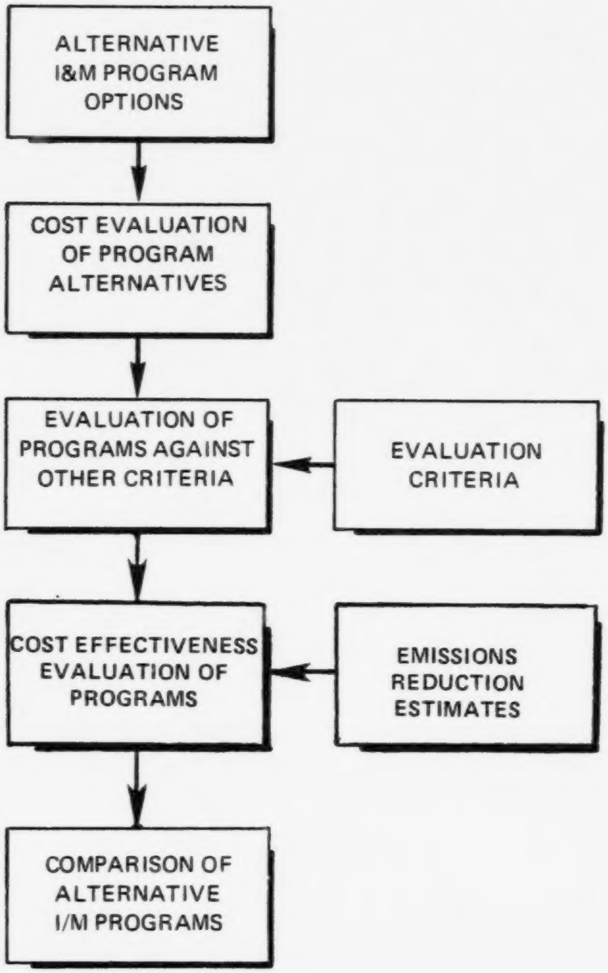
ALTERNATIVE I&M PROGRAM OPTIONS
COST EVALUATION OF PROGRAM ALTERNATIVES
EVALUATION OF PROGRAMS AGAINST OTHER CRITERIA
EVALUATION CRITERIA
COST EFFECTIVENESS EVALUATION OF PROGRAMS
EMISSIONS REDUCTION ESTIMATES
COMPARISON OF ALTERNATIVE I/M PROGRAMS

FIGURE 3
Overview of Approach
to Detailed Evaluation

Since the program will be self-supporting, all the above costs must be recovered by charging a fee for each vehicle inspected. The fee per vehicle multiplied by the number of vehicles tested will be the entire annual I/M budget. If the annual revenue from fees is insufficient to meet the debts incurred, the fee will have to be raised shortly following program implementation. This action could arouse public dissatisfaction and concern that the program is poorly managed. Thus, careful development of program cost estimates to establish the necessary fee is an essential step in planning for I/M as well as for comparing the costs of alternative I/M approaches. Thus, the objective of the cost analysis methodology was to estimate the total program costs and the fee per vehicle necessary to recover those costs, for each alternative I/M program.

(1) Overview of Cost Estimating Methodology

The basic approach employed in determining the inspection fee associated with an I/M program was based on the concept of life cycle costs. That is, all expenditures associated with development, implementation, and operation of each alternative I/M program during the life of the program was considered in determining the inspection fee. An overview of this approach is shown in Figure 4.

As shown in the figure, calculation of the inspection fee for each alternative program was determined by:

- First, calculating the life cycle costs associated with the State's, contractor's and/or private garage's involvement with the program
- Second, combining the life cycle costs computed for the State, contractor and/or the private garages to determine total program life cycle costs
- Third, calculating the number of vehicles which would be subject to inspection over the life of the program.

The inspection fee per vehicle was determined by dividing the total program life cycle costs by the total number of vehicles subject to inspection during the life of the program.

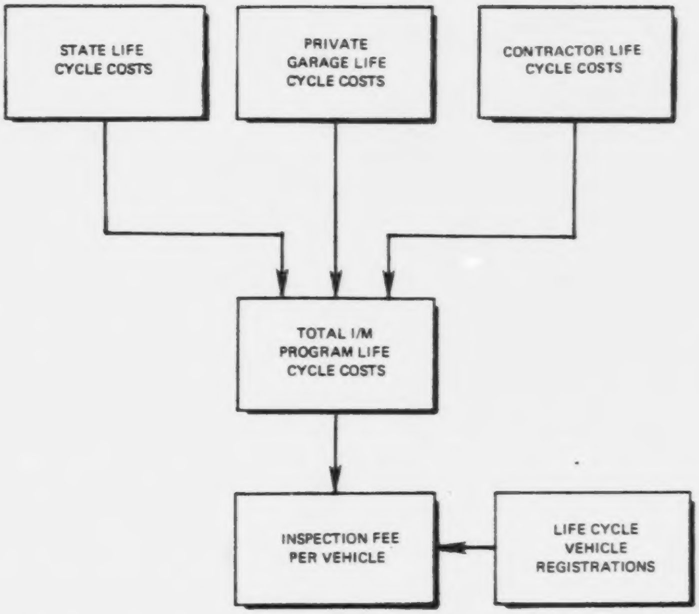
STATE LIFE CYCLE COSTS
PRIVATE GARAGE LIFE CYCLE COSTS
CONTRACTOR LIFE CYCLE COSTS
TOTAL I/M PROGRAM LIFE CYCLE COSTS
INSPECTION FEE PER VEHICLE
LIFE CYCLE VEHICLE REGISTRATIONS

FIGURE 4
Overview of Approach for
Determining Inspection Fee

The calculation of capital investment, start-up and operating costs for each alternative program was based on data received from existing I/M programs in other States, data gathered from discussions with local officials in each of the study areas, and conventional engineering cost estimating procedures. Wherever possible, site-specific data was used. A description of the principal steps in the above methodology is given in Appendix A.

(2) General Assumptions Made in Estimating the Costs

The emphasis of the cost analysis was to estimate the costs of the alternative I/M programs on a common basis rather than to optimize the costs of the individual I/M programs on a State-by-State basis. To this end, certain basic assumptions were made regarding all I/M programs, as follows:

- The programs would be self-supporting. That is, it was assumed that all costs incurred by either the State, contractor or private garage in development, implementation or operation of the I/M program would be passed on to the consumer through the inspection fee.

- The programs would only perform an emissions inspection, except in the Nebraska private garage-operated approach in which the emissions inspection would be added to the existing annual safety inspection program. Thus, in Nebraska, the total time required for a private garage emissions inspector to perform inspections as part of the annual safety inspection would be significantly less than in the other States.
- All initial investment and start-up costs (i.e., buildings, land and equipment) would be amortized over the life of the program so that they would be paid for entirely by the proposed I/M program. The cost of the land (plus appreciation) would be recovered at the end of the program.

In carrying out the cost analysis, the life of the program was assumed to be five years with a start-up date of January 1, 1981. This is consistent with the estimated life (for costing purposes only) of existing I/M programs. In addition (following from the initial screening) it was assumed that all light duty vehicles would be inspected, that a stringency factor of 30 percent would be employed and that mandatory maintenance and reinspection would be required of all vehicles not passing the inspection.

2. METHODOLOGY FOR EVALUATION OF INSTITUTIONAL I/M FACTORS

Since the objective of the study was to assist the States in determining the most suitable I/M program for each study areas, criteria in addition to cost were selected to distinguish among the alternative I/M programs. The following sections describe the other criteria used to evaluate the alternative I/M programs and the methodology used to conduct the evaluation.

(1) Evaluation Criteria

The criteria employed related to the institutional factors associated with implementing an I/M program as follows:

- Financial Feasibility. Although the cost of the I/M program is recovered by charging a fee for inspection, substantial initial capital investment is needed to start the program. The financial feasibility of the program depends upon the ability of the State, contractor or garage owner to raise the necessary capital.

- Ease of Implementation. The ease of implementation of an emissions I/M program is determined by the restrictions imposed by existing statutes and administrative procedures, the relationship with the existing safety inspection program, the degree of coordination required among the various governmental agencies involved, and the consistency with I/M programs in other areas.

- Flexibility for Future Modification. The flexibility is measured in terms of the ability of the State to expand or curtail the program's scope as needs change, and the ability of the program to accommodate improvements as the state-of-the-art of vehicles and test equipment change.

- Consumer Convenience. Consumer convenience is measured by the amount of time required for vehicle testing and retesting, as well as the location and operating hours of the testing facilities. For example, testing, repair and retesting which can be accomplished at the same time and place provide the greatest consumer convenience.

- Consumer Protection. Consumer protection afforded by an I/M program falls into two categories. First, the I/M program must ensure that the vehicle owners get a fair and accurate emissions test. Second, the I/M program must ensure that mandatory maintenance is performed. Third, if a vehicle does not meet the emissions standards, the program must provide for quality control of the repair process.

(2) Methodology

The methodology for evaluating the institutional factors associated with I/M included analyses of the State's legislative, financial and operating procedures; on-site personal interviews with the administrators of air quality and automotive safety inspection programs; and discussions with knowledgeable administrators of existing I/M programs in other areas. Members of the State and local planning agencies provided the following documentation:

- Detailed maps of the non-attainment counties
- Motor vehicle registrations, enabling legislation, reporting procedures and fees
- Organization charts of the State and local government agencies
- Motor vehicle safety inspection enabling legislation, schedules, procedures and fees
- Information on the fiscal practices of each State.

This information was used in conjunction with the personal interviews to evaluate the factors of financial feasibility, consumer convenience and flexibility for future modifications. Some specific analyses which were conducted included:

- Evaluation of the State government organization for vehicle registration, vehicle inspection and garage inspection activities to identify ways that responsibility for I/M might be distributed.
- Evaluation of State fiscal practices and budgets to determine the ability to raise sufficient capital for implementation of a State-operated program.
- Evaluation of each non-attainment region to compare the level of inconvenience which

might result from centralized inspection facilities with the inconvenience of decentralized facilities.

The information collected in discussions with I/M program administrators in other States was considered in evaluating the factors of consumer protection and ease of implementation. Their experience in dealing with the realities of State-, contractor- and private garage-operated programs contributed many useful insights to the evaluation of I/M for Kansas, Nebraska and Iowa. Other data sources employed in evaluating the factors of consumer protection and ease of implementation included recent technical papers on I/M,[10] and discussions with representatives from Hamilton Test Systems, Inc., various equipment manufacturers and EPA personnel in both Washington, D.C. and Ann Arbor, Michigan.

3. METHODOLOGY FOR EVALUATING I/M PROGRAM COST EFFECTIVENESS

The cost effectiveness of an I/M program is defined as the reduction in tons of hydrocarbon emissions per dollar spent for the program.* Cost effectiveness is determined by dividing the total costs of a program including the cost of repairing vehicles found defective through the emissions inspection program by the emissions reduction attributable to the program. The methodology for determining program costs other than repair costs was described in Section 1. Repair costs for emissions were estimated based on repair cost surveys in Arizona, Oregon, Tennessee, Alabama and New Jersey. The reduction in the emission of non-methane hydrocarbons in motor vehicle exhausts due to implementation of an I/M program was estimated by using the EPA computer program MOBILE-1, based on the following assumptions:

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* There are other factors which should also be included in a cost effectiveness analysis (e.g., reduction in health costs due to improved air quality) but these costs are not easily estimated and for this reason were not included in the analysis.

- A stringency factor of 30 percent
- Annual inspection
- Program implemented in 1981
- All light-duty vehicles beginning with model year 1968 included in the program.

The output of this program is presented for Iowa, Nebraska and Kansas in Chapters VI, VII and VIII, respectively.

V. EVALUATION OF CRITERIA COMMON TO ALL AREAS

This chapter presents the results of the detailed evaluation conducted for each of the alternative I/M program options independent of geographic considerations. The results are presented under the following headings:

- Ease of implementation
- Consumer convenience
- Consumer protection
- Flexibility for future modification
- Financial feasibility

1. EASE OF IMPLEMENTATION

Alternative approaches to I/M may be evaluated in terms of the amount of difficulty which the State will encounter in implementing each approach. Ease of implementation may be affected by:

- The Relationship of the Program to the Existing State Laws. Before an I/M program can be implemented, legislation must exist which gives authority to the appropriate State agencies for control of air pollution sources, inspection of motor vehicles, and definition and enforcement of standards.

- The Relationship of the Program to State Administrative Procedures. State administrative procedures that will affect the ease of implementation of an emissions I/M program include regulations for hiring and training personnel to staff new programs, the acquisition of land, buildings and equipment, and hiring of contractors by the State.

- The Relationship of the Program to the Existing Motor Vehicle Inspection Program. Combining safety and emissions inspection programs can be advantageous for a State in which the requirements for the two programs are compatible, such

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as in Nebraska where automobile safety inspections are conducted annually at certified private garages.

The advantages and disadvantages of each administrative approach with respect to ease of implementation are provided below.

(1) State-Operated Program

In a State-operated program all of the administrative and operational responsibilities of the program would lie solely with the State agencies. State limitations on hiring of employees, requirements that buildings and equipment meet certain specifications, rules and regulations regarding capital expenditures, and the time required to obtain approval and to effect program changes could have significant effects on the implementation of a State-operated program. State agencies wishing to employ personnel for such a program must request these personnel through the State Merit System. Since appropriations are based on specific personnel ceilings, requests for personnel to staff an emissions I/M program have to be approved by the State legislature in advance of the date they are actually required for operations of the program. Similarly, agency requests for estimated capital expenditures for land, buildings, and equipment to be used in State-operated centralized facilities must be appropriated by the legislature. However, land and buildings for such a program might be leased, rather than purchased, thus alleviating the requirement for large capital outlay by the State.

(2) Contractor-Operated Program

In contrast to the State-operated approach, in the contractor-operated approach the contractor would provide the capital for construction and operation of the inspection facilities. Obtaining a contractor to operate an I/M program, however, would involve a competitive procurement process authorized by the legislature. This could take considerable time. Experience in Arizona, for example, showed that two and one-half years were required for the program to become operational.[11] A contractor, on the other hand, has the flexibility to hire or curtail staff to meet varying demands without being constrained by State personnel procedures. In addition, a contractor may be able to raise capital more quickly to expedite implementation of the I/M program. The contractor approach would also relieve the State agencies of the burdens of testing, data collection, inspector training, and other operational details.

(3) Private Garage-Operated Program

The use of private garage-operated decentralized facilities offers many of the same advantages as the contractor-operated approach. In this approach, however, the State would have the responsibility for the certification of garages, training of inspectors, and quality control. In addition the State would have to provide a "challenge" garage to enable motorists to obtain an independent inspection with which to compare the results of a private garage inspection. Thus, buildings, land, equipment, and staff would have to be acquired by the State for this alternative; even though the State's capital investment and staff requirements for administration would be much smaller than for a State-operated program.

An advantage of the private garage-operated program over the State and contractor-operated approaches is where motor vehicle safety inspections are currently administered annually by certified garages. If an emissions inspection program were operated by private garages, implementation of the program would be somewhat facilitated by the existing administrative framework for licensing inspectors, certifying garages, and collecting inspection fees; although, these functions would have to be expanded and new staff added to handle the extra workload.

2. CONSUMER CONVENIENCE

Consumer convenience plays an important role in determining the public acceptance of inspection/maintenance programs. Consumer convenience may be measured by the following factors:

- Travel distance to the test facility
- The amount of time spent in testing and retesting, including waiting time
- The number of trips necessary to accomplish initial testing, repair, and retesting.

The decentralized approach (private garage) generally provides the greatest convenience to the motorist for all convenience factors since the required traveling distance is minimal, and testing, repair and retesting may be accomplished concurrently.

(1) State-Operated Program

The specific location of an inspection facility in a State-operated program is a function of land costs, politics, vehicle population, the capacity of the facility type and many other factors. As a result, there are a limited number of centrally located inspection stations in a State-operated program;* this places a distinct travel requirement on the motorist. Even with the optimal locations of facilities and the use of mobile vans to service outlying areas most motorists are required to travel out of their neighborhoods to obtain the emissions test. In addition to making a trip for the emissions test, the motorist whose vehicle exceeds the emissions standards must take the vehicle to be repaired and then return it to the central lane for reinspection, placing an additional burden on the motorist, especially if the vehicle needs to be tested more than one time.

Waiting and testing time in a State-operated inspection program is usually a function of the day of the month in which the motorist seeks the inspection as shown in Figure 5. Excessive waiting times in a State-operated program, however, may be alleviated through a strong public awareness campaign to encourage motorists to seek inspections earlier in the month. Another useful method of reducing waiting time is to stagger registration within each month so that the volume of inspections can be more evenly distributed.

The time required for the actual emissions test in a State-operated program ranges from two to five minutes and does not constitute an inconvenience to the consumer.

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*In the statewide New Jersey program, for example, there is an average of one station per county, with a few additional stations located in the most heavily populated areas.

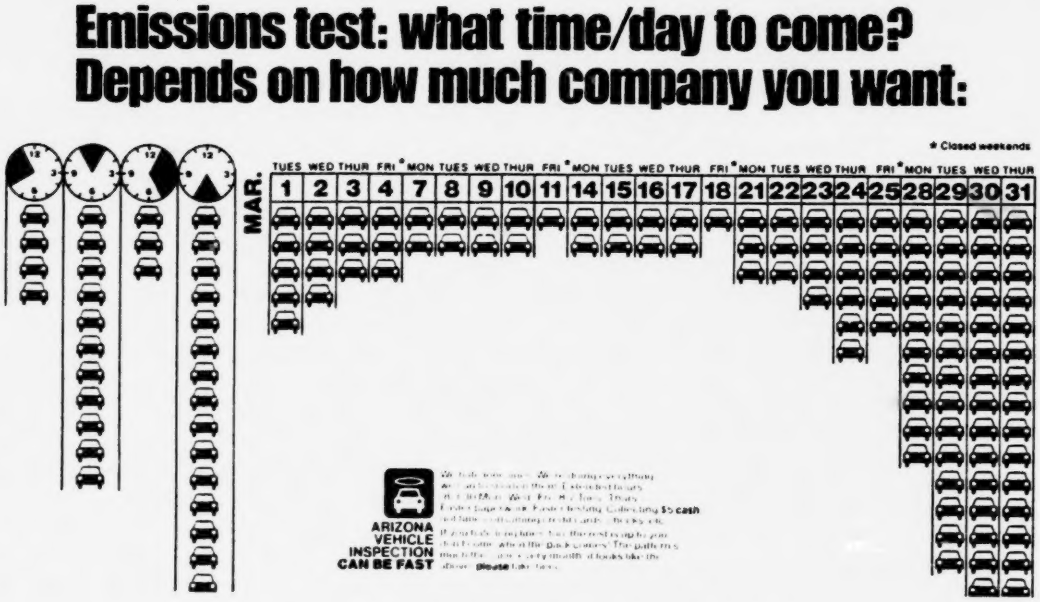

FIGURE 5
Emissions Test Waiting Periods: Arizona

(2) Contractor-Operated Program

Most of the consumer convenience characteristics of a State-operated program apply equally to a contractor-operated program since both approaches utilize centralized facilities. For example, traveling distance to the station for both the initial test and retest would be approximately the same, depending on the number and location of permanent lanes and the availability of mobile vans for remote areas.

Waiting times, however, may be more controllable in a contractor-operated program because of the contractor's flexibility in hiring temporary part-time inspectors to speed vehicle throughput during peak volume periods. As an added incentive for the contractor to reduce waiting time, the State may specify a maximum number of vehicles in any waiting line as a contract provision.

As in the case of the State-operated program, vehicle maintenance must be performed separately before the motorist returns to the contractor-operated lanes for retesting. Thus, the motorist is required to make two or more trips to accomplish testing, repair and retesting, depending on whether the vehicle is repaired by the owner or in a repair garage and is successfully or unsuccessfully repaired.

(3) Private Garage-Operated Program

A decentralized private garage I/M program offers the greatest convenience to the motorist. While the distance to the inspection station is a matter of preference, there should be a sufficient number of certified garages to reduce the necessary traveling distance to a maximum of three or four miles, compared to 10 to 15 miles for a State or contractor-operated program. This, of course, depends on the density of commercial repair facilities in each non-attainment area.

Private garage waiting times may or may not differ substantially from those of a centralized facility. If the line is very long at one garage, the motorist has the option of driving to a different garage with a shorter waiting line in the same neighborhood. The availability of this option implies a greater time savings in a decentralized program; but, in fact, the overall time spent in obtaining the inspection may be equivalent to a centralized inspection program if the motorist spends several minutes looking for an alternative inspection garage. In addition, since private garages lack the high throughput features of central facilities, the actual testing time in a private garage may be longer.

The most convenient aspect of the decentralized program is that the motorist may combine the initial test, maintenance, repairs, and retest in a single visit to the inspection station. Also, if the repairs and retesting are likely to take several hours, the motorist has the option of leaving his car at the garage for the service and retesting.

3. CONSUMER PROTECTION

In an I/M program motorists should be assured of receiving accurate test results, and should be protected as much as possible against faulty, excessive, inadequate, or fraudulent repairs. Generally, a centralized inspection approach provides the best protection to the consumer. Centralized facilities permit the use of standardized testing and calibration procedures, organized inspector training, and an objective retest following repair. In contrast, in a decentralized I/M program the chances of consumers receiving inaccurate tests are greater due to the difficulty in achieving uniform testing and enforcing calibration procedures. To offset the increased potential for inaccuracy, the EPA has recently defined certain basic requirements to assure consumer protection in a decentralized I/M program. The advantages and disadvantages of centralized and decentralized I/M programs regarding consumer protection are contrasted below.

(1) Centralized Inspection/Maintenance

A centralized inspection program has several advantages in providing consumers with accurate and consistent test results. In a centralized facility, each vehicle is tested by an independent organization having no special interest in auto repairs. The test is conducted in a high volume facility utilizing standardized procedures in conjunction with somewhat automated inspection equipment. If the vehicle exceeds the standards the motorist may have it repaired at the garage of his choice before returning the vehicle for a retest at the central inspection facility. The retest provides assurance to the motorist that the repairs were performed properly.

A central facility can also institute frequent equipment checks and continuous calibration on a daily or hourly basis. Because of the closely controlled environment, personnel and equipment performance can be monitored. Inspector training sessions can be held to correct improper testing procedures. A centralized inspection program facilitates automated data collection and analysis to eliminate errors in the recording of test results. All of these procedures present substantial advantages for protecting consumers against inaccurate test results.

(2) Decentralized Inspection/Maintenance

Conditions may exist in a decentralized inspection/maintenance program which may prevent motorists from receiving an accurate emissions test. For example, there is known to be limited standardization of inspection procedures, equipment maintenance and calibration schedules from one garage to another. In addition, garages are also subject to time and cost pressures on the use of a bay for inspections. Although the decentralized inspection program can incorporate additional consumer protection components, some consumer dissatisfaction may still result from the lack of consistency in the enforcement of emission standards among garages.

Methods to compensate for the lack of standardization of equipment calibration and inspection procedures include the following:

- Garage/Inspector Licensing Program. Garage and inspector licensing will ensure that the individual conducting inspections at the garage has received instruction in the proper use of the emissions analyzer and in vehicle testing methods. Licensing of the garages in addition will ensure that all garages have proper analytical instrumentation and sufficient space to provide inspections.

- Garage Inspection Program. By making inspections, the State garage inspectors can verify that the garages' equipment is calibrated, is in proper working order, and can provide accurate test results. This activity is a necessary element in a decentralized inspection program. Without surveillance the garages may allow their testing procedures and quality control to slip. The correlation of instrument readings among inspection facilities can also be checked at this time.

- Referee Inspection Stations (Challenge Garage). A referee station or challenge garage is a State-operated facility where vehicle owners may obtain an independent emissions test to compare to a test from a licensed station. As specified by EPA, at least one referee station must be present in each I/M metropolitan area where a decentralized program is in effect. There are no requirements for the size of the facility, thus it may take the form of a garage bay, a mobile van or even a portion of a parking lot, so long as the test methods are sound. Providing a referee station will give motorists an opportunity for an objective inspection, independent of any special interests of the repair industry. The challenge garage may also be a center for handling consumer complaints relating to the diagnosis and repair of vehicle malfunctions relating to emissions.

In carrying out the cost analysis, it was assumed that the above consumer protection methods would be incorporated into the decentralized I/M program under evaluation.

4. FLEXIBILITY FOR FUTURE MODIFICATION

Various program changes may become necessary after an I/M program has become operational. The amount of flexibility a program has to respond to program modifications is primarily a function of its administrative approach. This section describes the types of modifications which may occur and the relative flexibility of the three administrative approaches in accommodating them.

(1) State-Operated Program

The flexibility of a State-operated program depends on the amount of authority vested in the administering agency by the State legislature. Extensive revisions to the program may properly be limited to changes enacted by the legislature, but the State agency tasked with operation of the program must have substantial latitude to adjust technical and operational aspects of the program as the need arises. Areas where program changes may be needed and the flexibility which can be expected from a State-operated program are as follows:

- Changes in Emission Standards. Variations may be found in vehicle emissions and the burden of reducing mobile emissions by vehicle repairs and maintenance should not be concentrated among the owners of a few makes or models. While a State needs legislative authority to change specified emissions standards, a State-operated program should have sufficient flexibility to be able to adjust the standards as necessary. An example of this flexibility is the Portland program where engineers adjusted the standards continually until a set of standards was developed with unique specifications for each make/model group. The net result of these emission level adjustments was maximum equity in the standards for all makes and models being tested.

- Changes in Inspection Program Scope. If the State legislature authorizes the periodic inspection of vehicles for emissions, it may later wish to extend the program to include safety, noise, or even fuel economy. The National Highway Safety Administration has already begun a research program to demonstrate how this might be done.[12] A State-operated program may have an advantage over a contractor or garage operated program in extending emissions inspection to include safety or noise given sufficient space for inspections.

- Changes in Equipment or Program Operations. New emissions analyzing equipment will probably be needed after the program has been operating for approximately five years. This equipment will be desirable to assure continued accuracy in the inspection results, to upgrade testing technology and to provide additional testing capability. In the last five years, for example, available shop quality emissions testers have advanced from simple metered analyzers for hydrocarbon and carbon monoxide to machines with capabilities for digital readout, automatic printing of results, automatic calibration and analysis of CO_2. The administering agency of a State-operated I/M program may have considerable flexibility in judging the need for new equipment. In addition, a State-operated program should have considerable flexibility in other program areas such as operating hours, waiver monitoring, public relations, and data analysis.

(2) Contractor-Operated Program

A private contractor-operated I/M program may provide flexibility equivalent to a State-operated program in many areas. However, an agreement with a contractor may call for extensive negotiations prior to any changes affecting the cost of performing inspections. These negotiations may delay implementation of the changes and consume the time and energy of the administering State agency.

One advantage of the contractor-operated program over the State-operated program is in operation of the inspection program. Acquisition of additional land, buildings, and equipment, expansion of staff and other activities which result from growth are less constrained in the private sector than in the public sector. Consequently, if the I/M program must be expanded in the future to include additional counties, the contractor may be able to move more quickly in setting up new inspection facilities. Similarly, the contractor has considerable flexibility in increasing or decreasing the size of the inspection staff as the inspection volume changes over the course of the program.

(3) Garage-Operated Program

Since a decentralized program has more facilities and inspectors than a centralized program, procedural changes must be communicated to a larger and more dispersed group. In contrast to the State- and contractor-operated program, the garage-operated I/M program is less flexible in the matter of changes to emissions standards because of the large number of facilities. Similarly, changes in inspection equipment are less flexible in a private garage-operated system since the selection and replacement of equipment is the prerogative of the private garage owner. The advantages of a private garage-operated program in terms of flexibility are in changes to inspection program scope and program operation as follows:

- Changes in Inspection Program Scope. The private garage approach to I/M may provide the greatest flexibility for expansion to a combined safety/emissions inspection in those States with an existing private garage-operated periodic safety inspection program. A change of ownership safety inspection program could be extended to include annual safety/emission inspections. An alternative approach would be to operate separate garage inspection programs, one for an annual emissions test and one for the existing change of ownership safety inspection.

- Changes in Program Operations. The private garage approach provides considerable flexibility in expanding an I/M program to additional geographic areas. No land or building purchase is necessary -- only the licensing of garages in the additional areas is needed.

FINANCIAL FEASIBILITY

The financial feasibility of an I/M program option depends primarily upon the ability of the State, contractor, or private garage owner to raise the necessary capital for land, buildings, and equipment. In general the contractor has several options for raising the capital needed for land, buildings, and equipment including borrowing from a bank or issuing industrial revenue bonds. Similarly, a private garage owner could borrow the capital needed for an exhaust gas analyzer, approximately $2,200, from a local bank or credit union. The State also has several different options to raise the necessary capital for land, buildings, and equipment including borrowing the money from the State's general fund or through the issuance of long term debt.

Operating costs are not a major factor in determining the financial feasibility because of the revenue generated during the program operation. Similarly, program start-up costs, although substantial for any I/M program would not affect the financial feasibility of the program because these costs could be deferred through the prudent use of the State's existing cash flow fund.

* * * * * *

This chapter presented an evaluation of the three administrative approaches according to five criteria common to all of the study areas. In general, the garage and contractor approaches offer greater ease of implementation than the State-operated approach, and the garage approach also offers the greatest consumer convenience. Consumer protection, on the other hand, is more easily provided by either the State or contractor approach since they offer central facilities with uniform procedures. The State-operated program offers the greatest flexibility for future modification since it involves the least separate organizations in program operation.

VI. EVALUATION OF I/M PROGRAMS FOR IOWA

This chapter presents the results of the detailed evaluation conducted for the five I/M programs in the three Iowa non-attainment areas (Polk, Scott and Pottawamie Counties). The first section describes the study area and identifies some of its key demographic and physical features. In the second section, the results of a detailed cost analysis of each of the five program types are presented. Section 3 analyzes the financial feasibility of the different programs based on capital requirements for the State. Section 4 presents the results of a cost effectiveness analysis while Section 5 summarizes the findings of other significant issues investigated. Finally, Section 6 summarizes the evaluations of the five program types and presents conclusions for Iowa.

1. DESCRIPTION OF STUDY AREA

This study evaluated the prospects of alternative vehicle emissions inspection/maintenance programs in Polk, Pottawattamie and Scott Counties, Iowa. A map of the State, shown in Figure 6, illustrates the locations of the three affected counties as well as the major political jurisdictions within the counties. Table 4 describes some of the key demographic and physical features of the three counties.

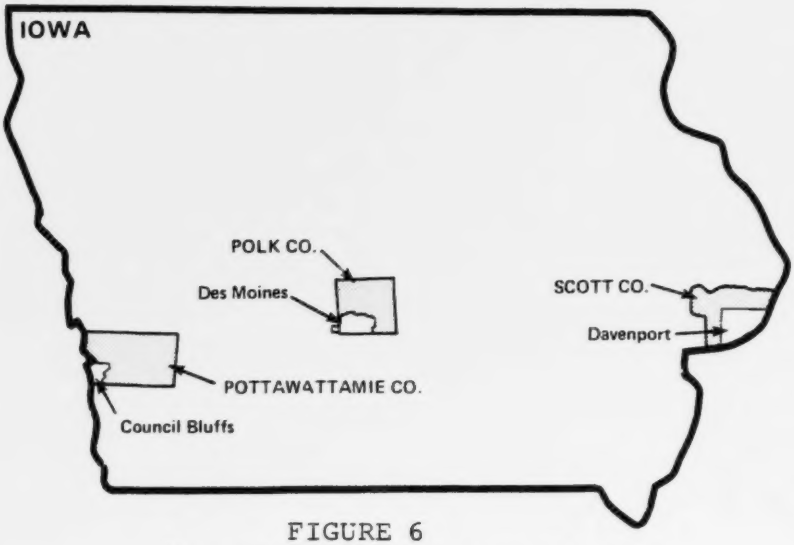

FIGURE 6
Map of Iowa Study Area

TABLE 4
Key Features of Scott, Polk, and Pottawattamie Counties, Iowa

SCOTT COUNTY (Davenport)	
Population:	151,800
Area:	1412 square kilometers (545 square miles)
Population Density:	108 persons per square kilometer (278 persons per square mile)
1977 Registered Light Duty Vehicles:	110,000
POLK COUNTY (Des Moines)	
Population:	303,200
Area:	1497 square kilometers (578 square miles)
Population Density:	202 persons per square kilometer (525 persons per square mile)
1977 Registered Light Duty Vehicles:	220,000
POTTAWATTAMIE COUNTY (Council Bluffs)	
Population:	86,500
Area:	2494 square kilometers (963 square miles)
Population Density:	35 persons per square kilometer (90 persons per square mile)
1977 Registered Light Duty Vehicles:	60,000

2. COST ANALYSIS RESULTS

This section presents the results of the life cycle cost analysis for the five I/M programs options in Iowa. Although costs were estimated for the specific requirements of each non-attainment area, only the total life cycle costs and inspection fees are shown. All costs were estimated for a life cycle of five years, 1981 to 1985, and are referred to in the report as "current" dollars.* Several assumptions, however, were necessary to estimate the costs in the study (e.g., level of inspection automation, number of employees in program administration, and the average inflation rate over the period 1978 to 1985). As a result, actual program costs may vary from the cost estimates presented herein depending upon the actual program design.

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* Current dollars is an economic term used to denote actual dollar values at a particular point in time.

The section is divided into four parts, as follows:

- Summary of capital investment, start-up and operating costs
- Summary of costs to the State
- Summary of life cycle costs
- Summary of fee calculations

(1) Summary of Capital Investment, Start-Up and Operating Costs

Table 5 identifies the major cost results from the analysis. Capital investments and start-up costs vary from $1.1 million to $4.3 million depending on the type of facility used (centralized or private garage). The centralized programs required 2.5 times the capital investment of the private garage program for the idle test. Conversely, the private garage program has 2.5 times the annual operating cost of the centralized program for an idle mode test. Overall, the private garage program is 85 percent more costly than the centralized programs. The loaded mode test is about 45 percent more costly than the idle mode test.

TABLE 5
State of Iowa
Summary of Cost Analysis Results

Program Type	Capital Investments and Start-Up Costs	Average Annual Operating Costs	Average Annualized Costs
State Operated			
Idle	$2,800,000	$1,100,000	$1,800,000
Loaded	4,300,000	1,600,000	2,600,000
Contractor Operated			
Idle	2,800,000	1,000,000	1,800,000
Loaded	4,300,000	1,500,000	2,700,000
Private Garage Operated			
Idle	1,100,000	2,700,000	2,900,000

(2) Summary of Costs to the State

Table 6 summarizes the cost to the State of the different I/M program options. Capital investments for State-operated programs would be $2.3 million for the idle test and $3.8 million for the loaded test. State start-up costs would vary from $100,000 to $500,000. The State's involvement in the contractor program would be minimal (9 to 13 percent of the cost). For the private garage, the involvement, however, is somewhat higher (12 percent of the cost). The number of State employees would vary from eight in the contractor program to 75 in the loaded test State-operated program. The private garage program would require 14 State employees, a significant number of them taking responsibility for program enforcement.

TABLE 6
State of Iowa
Summary of Costs to the State
Current Dollars (Life Cycle 1981-1985)

Program Type	Initial State Capital Investments	Initial State Start-Up Costs	Average Annual State Operating Costs	State Costs as Percent of Total Program Cost	Number of State Employees
State Operated					
Idle	$2,300,000	$500,000	$1,100,000	100%	52
Loaded	3,800,000	500,000	1,600,000	100	75
Contractor Operated					
Idle	0	100,000	200,000	13	8
Loaded	0	100,000	200,000	9	8
Private Garage Operated					
Idle	8,000	300,000	300,000	12	14

(3) Summary of Life Cycle Cost Elements

Table 7 presents the estimates for system costs over the 1981 to 1985 life cycle of the programs for all five I/M options. All of the costs are given in 1978 dollars. The costs are separated into three categories: capital investments, start-up and operating. Both the capital investment and the start-up costs are incurred in the year preceding the program start date. The operating costs are estimated over the program life cycle. Details of the assumptions and calculations for these data are given in Appendix D.

(4) Fee Calculation Summary

Table 8 illustrates the results of the fee calculation for the five program types. The sum of the average annualized capital investment and start-up cost and the average annualized operating cost (one-fifth of the life cycle operating cost) equals the total average annualized cost. This figure is divided by the average annual number of light duty vehicles to get an average annual fee per vehicle.

As shown in Table 8, the results indicate that in Iowa the State-operated program would be the least expensive alternative; however, the contractor-operated program would be only 7 percent more expensive. The annual fee per vehicle for a State-operated program would be $3.50 for an idle-mode test and $5.25 for a loaded mode test. For a contractor-operated program, the annual fee for an idle test would be $3.75 and $5.50 for a loaded test. For the private garage, the annual fee would be $6.50.* The above fees represent an average over the five-year period, 1981 to 1985.

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* The costs for the private garage-operated programs were estimated at a fully loaded rate (hourly garage service rate). Although the current practice in many private garage-operated safety inspection programs is for private garages to absorb some of the labor costs due to a perceived opportunity benefit of performing repairs on defective vehicles, it is not clear that this will continue for emissions inspections. Even if this was to be the case, this study compares actual costs of alternatives. Therefore, the full, actual costs are estimated and presented, regardless of whether they would be charged directly or passed on elsewhere.

TABLE 7
State of Iowa
Five Year Life Cycle Cost Element Summary
(1978 Dollars)

Cost Element*	State-Operated		Contractor-Operated		Private Garage-Operated
	Idle	Loaded	Idle	Loaded	Idle
CAPITAL					
Building	$ 900,000	$1,600,000	$ 900,000	$1,600,000	–
Land	300,000	500,000	300,000	500,000	–
Equipment – State	800,000	1,200,000	–	–	$ 7,000
– Contractor	–	–	800,000	1,200,000	–
– Garage	–	–	–	–	600,000
START-UP					
Labor – State	200,000	200,000	100,000	100,000	100,000
– Contractor	–	–	100,000	100,000	–
Program Design	100,000	100,000	100,000	100,000	100,000
Public Information	100,000	100,000	100,000	100,000	100,000
Training	10,000	20,000	10,000	20,000	–
OPERATING					
Labor – State	3,700,000	5,100,000	800,000	800,000	1,100,000
– Contractor	–	–	2,700,000	3,900,000	–
– Garage	–	–	–	–	10,500,000
Equipment Maintenance	200,000	400,000	200,000	400,000	–
Public Information	200,000	200,000	200,000	200,000	200,000
Other Operating Costs	200,000	400,000	200,000	400,000	–

*Details of cost elements in Appendix D.

TABLE 8
State of Iowa Fee Calculation Summary
Current Dollars (Life Cycle 1981-1985)

	State-Operated		Contractor-Operated		Private Garage-Operated
	Idle	Loaded	Idle	Loaded	Idle
Annualized Capital and Start-up Cost					
State	$ 700,000	$1,000,000	$ 30,000	$ 30,000	$ 100,000
Contractor	–	–	700,000	1,000,000	–
Garage	–	–	–	–	200,000
Average Annual Operating Cost					
State	1,100,000	1,600,000	200,000	200,000	300,000
Contractor	–	–	800,000	1,300,000	–
Garage	–	–	–	–	2,700,000
Average Annual Contractor Profit	–	–	100,000	200,000	–
Total Average Annualized Cost					
State	1,800,000	2,600,000	230,000	230,000	400,000
Contractor	–	–	1,600,000	2,500,000	–
Garage	–	–	–	–	2,900,000
Average Annual Fee-Producing Vehicles	500,000	500,000	500,000	500,000	500,000
Average Annual Fee Per Vehicle					
State	$3.50	$5.25	$0.50	$0.50	$ .75
Contractor	–	–	3.25	5.00	–
Garage	–	–	–	–	5.75
TOTAL	$3.50	$5.25	$3.75	$5.50	$6.50

3. FINANCIAL FEASIBILITY

Iowa has the capability of financing vehicle inspection facilities. Three sources were considered for this funding, estimated at a maximum of $3.8 million. The most likely source is the State's general fund.[13] This fund, budgeted at $1.6 million for FY79, is expected to contain a surplus of $80 million on July 1, 1979.[14] The $3.8 million required is 0.24 percent of the 1979 budget, and 4.7 percent of the expected surplus.

A less likely source of capital funds is the State highway fund. The State operates under the premise that these funds must be used only for the maintenance of State highways and for the associated promotion of public safety.[15] Thus, while the highway fund may be large in terms of total dollars, it presently is not a legally viable source of capital funds for the inspection program.[16] A cooperative effort being undertaken by the Department of Transportation and EPA could lead to the availability of these funds in the future.[17]

The final option available to the State is the issuance of long term debt. This is not a practical alternative in Iowa.[18] An amendment to the State Constitution is needed if the State is to incur additional general obligation debt. The process of gaining voter approval for the amendment would not be cost-effective in this case. Revenue bonds, on the other hand, would require specific approval by the State legislature. Revenue bonds are used only occasionally in Iowa, and their issuance would not be cost-effective in this case.[19]

In summary, Iowa has the capability to finance the capital requirements of the inspection program. The $3.8 million requirement is small compared to the State's general fund (0.24 percent), the expected $80 million budget surplus (4.7 percent), and the total personal income (0.01 percent). The anticipated $80 million surplus in the general fund could be the sole source of capital for the inspection program.[20] A political decision would have to be made by the State legislature to commit a portion of this fund to the program.

4. EMISSIONS REDUCTION AND COST EFFECTIVENESS

As discussed in Chapter II, one of the major benefits of an I/M program is the emissions reduction that can be achieved through the periodic inspection of motor vehicles. A summary of these potential benefits for the non-attainment areas in Iowa (based on the Mobile 1 computer program) is shown in Table 9. As shown, it is estimated that emissions reductions of up to 20.7 percent can be achieved by implementing an I/M program in these areas. This is regardless of the type of I/M program. It should be noted, however, that the version of the Mobile-1 program used for this analysis only evaluated the application of the I/M program to automobiles, whereas the I/M programs evaluated in this report also include light duty trucks. The potential reduction in hydrocarbon emissions from motor vehicles due to the I/M programs for the study areas would, therefore, be greater than the estimates given in Table 9. Furthermore, the potential reduction in motor vehicle emissions in the study area could be increased by raising the stringency factor and/or including heavy duty vehicles and motorcycles in the program. The choice of stringency factor and vehicle types subject to I/M would depend upon the amount of emissions reduction desired in the study areas.

Table 10 summarizes the results of the cost effectiveness analysis for Iowa non-attainment areas. Although the results of the cost effectiveness analysis do not yield additional information from a comparative perspective (they are directly related to the program cost results presented in Section 2), they can be compared to cost effectiveness results for other air quality programs.

5. OTHER SIGNIFICANT FACTORS FOR IOWA

Other significant factors to be considered in Iowa include the current safety inspection, State agencies with functions related to I/M, the Iowa air pollution control laws and consumer convenience. Each is discussed briefly below.

(1) Current Safety Inspection

In Iowa, motor vehicle safety inspections are performed at change of ownership by private garages which are certified by the Iowa Department of Transportation. The uniform inspection fee is $8.00, of which $.25 is retained by the State and the remainder goes to the inspection station.

TABLE 9
Projected Reduction in Non-Methane Hydrocarbons (NMHC) in Motor Vehicle Exhaust Due to I/M Implementation

	SCOTT COUNTY (Davenport Area)	**POLK COUNTY (Des Moines Area)**	**POTTAWATTAMIE COUNTY (Council Bluffs Area)**
Projected 1987 NMHC emissions without I/M* (tons per year)	3,088	5,469	2,139
Projected 1987 NMHC emissions with I/M** (tons per year)			
• Without mechanic training	2,683	4,753	1,859
• With mechanic training	2,449	4,337	1,709
Projected 1987 NMHC reduction due to I/M (tons per year)			
• Without mechanic training	405	716	280
• With mechanic training	639	1,132	430
Projected 1987 NMHC reduction due to I/M			
• Without mechanic training	13.1%	13.1%	13.1%
• With mechanic training	20.7%	20.7%	20.7%

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*Source: Iowa Department of Transportation.

**Projection based on similar results for Kansas. Iowa results were not available at time of publication.

TABLE 10
Summary of Cost Effectiveness Results

Program Type	1987 NMHC* Reduction (tons)	Projected 1987 I/M Program and Vehicle Repair Costs** (millions)	NMHC Reduction per Dollar Spent (pounds per dollar)
POLK COUNTY			
State-Operated			
Idle	1,132	$3.0	0.75
Loaded	1,132	3.6	0.63
Contractor-Operated			
Idle	1,132	3.1	0.73
Loaded	1,132	3.7	0.61
Private Garage-Operated	1,132	4.1	0.55
POTTAWATTAMIE COUNTY COUNTY			
State-Operated			
Idle	430	$0.8	1.07
Loaded	430	1.0	0.86
Contractor-Operated			
Idle	430	0.9	0.95
Loaded	430	1.0	0.86
Private Garage-Operated	430	1.1	0.78
SCOTT COUNTY			
State-Operated			
Idle	639	$1.5	0.85
Loaded	639	1.9	0.67
Idle	639	1.6	0.80
Loaded	639	1.9	0.67
Private Garage-Operated	639	2.1	0.61

*Non-methane hydrocarbons

**See Appendix D for details

Since Iowa does not have an annual safety inspection, combination of the emission and safety inspections in the private garages is not feasible. A garage based emission inspection program could be operated by the garages in addition to the safety program with the tests conducted separately. A centralized emission inspection program could also be operated in parallel with the existing decentralized safety inspection program. The safety inspection is not a determining factor in the selection of an I/M approach in Iowa.

(2) Iowa Agencies with Functions Relevant to an I/M Program

The Iowa Departments of Environmental Quality, Transportation, Revenue and Public Safety are listed in Table 11 with their specific functions which are related to I/M. One component of a decentralized I/M program, periodic garage inspections, is already provided by the Department of Transportation. In addition, draft air pollution control legislation specifies that periodic motor vehicle emissions inspection will be enforced by the Department of Transportation and the Department of Public Safety. Regardless of the approach selected, these agencies will serve as the enforcing State organizations.

TABLE 11
Existing Iowa State Agencies with
Functions Relevant to an I/M Program

Department	Division	Functions
Environmental Quality	Air Quality Management	Enforce air quality regulations Analyze air quality data
Transportation	Motor Vehicle Division, Office of Safety Programs	Grant permits for safety inspection stations Enforce safety inspection standards
County Treasurer (State Revenue)	Vehicle Registration	Receive applications for registration and title Receive safety inspection certificates
Public Safety		Enforce safety regulations

(3) Existing Air Pollution Control Laws

Current Iowa law (Section 455 B.12 of the Iowa Code) gives the Air Quality Commission broad authority to direct the development of a comprehensive plan for the abatement, control and prevention of air pollution in Iowa. In addition to this general mandate, proposed legislation sets forth specific regulations for automobile emissions and enforcement of applicable standards. Principal provisions of the draft Air Pollution Control and Energy Supply Act include:

- Revising the authority of the Department of Environmental Quality to regulate sources of air pollution.
- Authorizing the establishment and enforcement of air quality standards for motor vehicle emissions.

Passage of this legislation will be the first step toward implementation of an I/M program in Iowa. Neither the current law nor proposed legislation favors one of the I/M approaches over the others.

(4) Consumer Convenience

The consumer convenience of alternative I/M approaches may be measured by the distance to each station and the amount of waiting time before the test. Althought it is difficult to accurately predict waiting times for centralized and decentralized programs, a comparison can be made between the number of stations called for in each approach. From this comparison, the differences in consumer convenience may be predicted.

In Scott and Pottawattamie Counties it is estimated that there will be 35 times more inspection stations in a decentralized program than in a centralized program (104 decentralized stations and 3 centralized stations). A rough analysis indicates that on the average, a motorist would have to travel about six times as far to get to a centralized station as to decentralized station.

Due to the large size of Pottawattamie County and the sparsely populated areas in the eastern half of the county it may be necessary to modify the centralized I/M program options to improve convenience. The basic design requires motorists from the eastern part of the county to travel considerable distances to reach an inspection station. There are two ways to modify the program to prevent this. The first is to limit the program to only those townships in the county which are urbanized. This would include Kane, Garner, Lake and Lewis Townships. Although limiting the program to these townships would not significantly impact the costs, this may not be an acceptable revision to the SIP.

The other way of modifying the program to improve convenience requires a mobile test facility to serve the outlying areas, in addition to the central facility. The cost of a mobile unit (approximately $100,000*) would add about six cents to the fee of the Iowa centralized program.

6. EVALUATION SUMMARY

This section summarizes the findings of the evauluation of I/M programs for Iowa and presents the conclusions. A comparison of the five I/M program alternatives is shown in Table 12. The table compares the following findings:

- The costs of the State- and contractor-operated programs are comparable and are approximately 45 percent lower than the private garage-operated program.
- The costs of the State- and contractor-operated loaded test programs are approximately two-thirds higher than corresponding idle test programs.
- All programs are financially feasible since they will be self-supporting. A political decision to allocate a portion of the State General Fund to meet the capital investment needs of the State-operated program must be made by the legislature.

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* Based on data obtained from the Chicago I/M program.

TABLE 12
Comparison of I/M Program Options for Iowa

Program Type	Cost Per Vehicle	Average Cost Effectiveness (Pounds of Non-Methane Hydrocarbons Reduced Per Dollar Spent)	Financial Feasibility	Ease of Implementation	Consumer Convenience	Consumer Protection	Flexibility For Future Modification
STATE							
Idle	$3.50	0.83	Programs will be self supporting. State capital investment needs are substantial ($2.3 to $3.8 million) but are small compared to State general fund	**Low**: May face administrative constraints in hiring or curtailing staff and acquiring land, buildings and equipment.	**Low**: Limited number of central testing facilities requires travel for test and retest. Repair must be done elsewhere.	**High**: Quality of testing and repairs can be effectively controlled and monitored.	**High**: State has direct control over the entire program.
Loaded	5.25	0.67					
CONTRACTOR							
Idle	3.75	0.78	Programs will be self-supporting, no State capital investment needed.	**High**: Contractor can hire or curtail staff and acquire land, buildings and equipment without administrative constraints, relieves State of operating responsibilities.	**Low**: Limited number of central testing facilities requires travel for test and retest. Repair must be done elsewhere.	**High**: Quality of testing and repairs can be effectively controlled and monitored.	**Medium**: Changes in program must be negotiated with the contractor.
Loaded	5.50	0.67					
PRIVATE GARAGE							
Idle	6.50	0.60	Program will be self-supporting, minor State capital investment needed.	**Medium**: Infrastructure of existing change of ownership safety inspection program would ease implementation, but State must still manage program.	**High**: Large number of garages distributed throughout the study areas for easy access. Provides opportunity for one stop test, repair, and retest.	**Low to Medium**: Depending upon the effectiveness of quality control measures for testing and repairs.	**Low**: State must deal with a large number of private garages to make changes effective.

- Since an infrastructure for a private garage operated safety inspection already exists (change of ownership), a private garage-operated emissions program would face the fewest admistrative constraints. In addition, the contractor-operated program would not face administrative constraints as stringent as the State-operated programs.

- Consumer convenience is high with the private garage approach because a large number of garages can be certified to perform the test providing easy access to motorists. A private garage also provides an opportunity for one-stop test, repair, and retest. The centralized State- and contractor-operated programs place some travel requirements on persons not in the vicinity of the inspection station. If a vehicle does not pass the emission test, it must be repaired in a garage or at home and taken again to the inspection station for a retest. In particular, residents in outlying parts of Pottawattamie County must travel a long distance to reach a test facility. A mobile test facility will improve convenience by circulating to the outlying areas.

- Consumer protection is high with the centralized programs. The quality of inspection can be effectively controlled since a limited number of facilities are involved. The State- and contractor-operated programs also provide an objective check on the quality of repairs performed by the repair industry by monitoring vehicles requiring a retest. The degree of consumer protection afforded by the private garage-operated program increases with the effectiveness of the State quality control programs such as certification of garages and inspectors, calibration checks, spot checks and challenge garages, but is still lower than that afforded by the State or contractor approach.

- Flexibility for future modifications such as adjustments in emission standards and equipment is high with the State-operated program since the State has direct control over program administration and operation. The contractor approach has comparable flexibility, except that changes may have to be negotiated with the contractor. Because of the large number of garages involved in the private garage-operated program, the flexibility for program modification is low since the changes must be simple enough to be uniformly implemented.

* * * * * *

It is clear from the comparison in Table 12 that none of the alternative I/M programs is the most preferred for all criteria. The selection of the most preferred program depends upon the relative importance of each of the evaluative criteria.

If the cost of the program to the motorist is considered as the only important criterion, then there would not be a significant difference between the State and contractor-operated program. The loaded test programs would be less desirable than the idle test programs.

Since the other criteria will likely play a significant role in determining the preferred option, each decision-maker must weigh the relative importance of the criteria in conjunction with the results of the evaluation before reaching a decision. If each of the criteria were given equal weight, then the State-operated approach would be the most desirable for Iowa primarily due to its low cost and flexibility for future modification.

VII. EVALUATION OF I/M PROGRAMS FOR KANSAS

This chapter presents the results of the detailed evaluation conducted for the five I/M programs in the three Kansas non-attainment areas (Johnson, Wyandotte, and Sedgwick Counties). The first section describes the study area and identifies some of its key demographic and physical features. In the second section, the results of a detailed cost analysis of each of the five program types are presented. Section three analyzes the financial feasibility of the different programs based on capital requirements for the State. Section four presents the results of a cost effectiveness analysis conducted while section five summarizes the findings of other significant issues investigated. Finally, section six summarizes the evaluations of the five program types and presents conclusions for Kansas.

1. DESCRIPTION OF STUDY AREAS

Wichita and Kansas City are approximately 440 kilometers (200 miles) apart in the eastern half of the State. Wichita is contained entirely within Sedgwick County and Kansas City is contained in Wyandotte County. Johnson County is adjacent to Wyandotte County. Figure 7 illustrates the relationship among these three counties. Key features of each area are shown in Table 13.

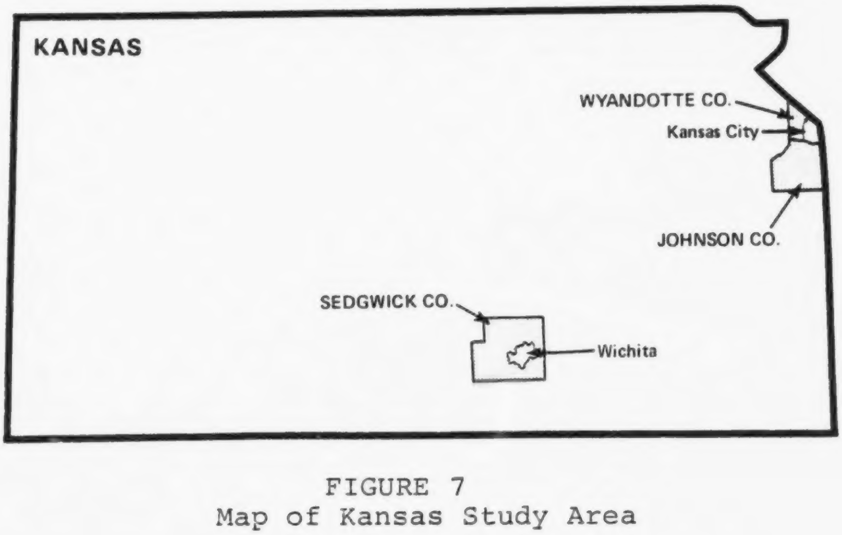

FIGURE 7
Map of Kansas Study Area

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TABLE 13
Key Features of Johnson, Wyandotte and Sedgwick Counties, Kansas

JOHNSON AND WYANDOTTE COUNTIES (Kansas City)	
Population:	430,500
Area:	1523 square kilometers (588 square miles)
Population Density:	283 persons per square kilometer (732 persons per square mile)
1977 Registered Light Duty Vehicles:	280,000
SEDGWICK COUNTY (Wichita)	
Population:	342,500
Area:	2720 square kilometers (1050 square miles)
Population Density:	126 persons per square kilometer (326 persons per square mile)
1977 Registered Light Duty Vehicles:	230,000

2. COST ANALYSIS RESULTS

This section presents the results of the life cycle cost analysis for the three I/M programs options in Kansas. Although costs were estimated for the specific requirements of each non-attainment area, only the total life cycle costs and inspection fees are shown. All costs were estimated for a life cycle of five years, 1981 to 1985 and are referred to in the report as "current" dollars*. Several assumptions were necessary to estimate costs in the study (e.g., level of inspection automation, number of employees in program administration, and the average inflation rate over the period 1978 to 1985). As a result, actual program costs may vary from the cost estimates presented herein depending upon the actual program design.

The section is divided into four parts, as follows:

- Summary of capital investment, start-up and operating costs
- Summary of costs to the State

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* Current dollars is an economic term used to denote actual dollar values at a particular point in time.

Summary of life cycle costs
Summary of fee calculations

(1) Summary of Capital Investment, Start-Up and and Operating Costs

Table 14 identifies the major cost results from the analysis. Capital investments and start-up costs vary from $1.3 million to $6.0 million depending on the type of facility used (centralized or private garage). The centralized programs require 2.75 times the capital investment of the private garage program for the idle test. Conversely, the private garage program has three times the annual operating costs of the centralized program for an idle mode test. Overall, the private garage program is approximately 80 percent more costly than the centralized programs. The loaded mode test is 50 percent more costly than the idle mode test.

TABLE 14
State of Kansas
Summary of Cost Analysis Results
Current Dollars (Life Cycle 1981 - 1985)

Program Type	Capital Investments and Start-Up Costs	Average Annual Operating Costs	Average Annualized Costs
State Operated			
Idle	$3,600,000	$1,200,000	$2,000,000
Loaded	6,000,000	1,700,000	3,000,000
Contractor Operated			
Idle	3,600,000	1,100,000	2,100,000
Loaded	6,000,000	1,500,000	2,900,000
Private Garage Operated			
Idle	1,300,000	3,600,000	3,900,000

(2) Summary of Costs to the State

Table 15 summarizes the cost to the State of the different I/M program options. Capital investments for State-operated programs are $3.0 million for the idle test and $5.4 million for the loaded test. State start-up costs vary from $100,000 to $600,000. The State's involvement in the contractor program is minimal (nine to twelve percent of the cost). For the private garage, the involvement, however, is somewhat higher (15 percent of the cost). The number of State employees varies from eight in the contractor program to 81 in the State-operated program. The private garage program has 16 employees, a significant number of them responsible for program enforcement.

TABLE 15
State of Kansas
Summary of Costs to the State
Current Dollars (Life Cycle 1981 - 1985)

Program Type	Initial State Capital Investments	Initial State Start-Up Costs	Average Annual State Operating Costs	State Costs as Percent of Total Program Cost	Number of State Employees
State Operated					
Idle	$3,000,000	$600,000	$1,200,000	100%	52
Loaded	5,400,000	600,000	1,700,000	100	81
Contractor Operated					
Idle	0	100,000	200,000	13	8
Loaded	0	100,000	200,000	10	8
Private Garage Operated					
Idle	5,000	500,000	400,000	15	16

(3) Summary of Life Cycle Cost Elements

Table 16 presents the estimates for system costs over the 1981 to 1985 life cycle of the programs. All of the costs are given in 1978 dollars. The costs are separated into three categories: capital investments, start-up and operating. Both the capital investments and the start-up costs are incurred in the year preceding the program life cycle. Details of the assumptions and calculations for these costs are given in Appendix D.

TABLE 16
State of Kansas
Five Year Life Cycle Cost Element Summary
(1978 Dollars)

	State-Operated		Contractor-Operated		Private Garage-Operated
Cost Element*	Idle	Loaded	Idle	Loaded	Idle
CAPITAL					
Building	$ 900,000	$1,800,000	$ 900,000	$1,800,000	–
Land	900,000	1,700,000	900,000	1,700,000	–
Equipment – State	800,000	1,200,000	–	–	$ 4,000
– Contractor	–	–	800,000	1,200,000	–
– Garage	–	–	–	–	700,000
START-UP					
Labor – State	200,000	200,000	100,000	100,000	100,000
– Contractor	–	–	100,000	100,000	–
Program Design	100,000	100,000	100,000	100,000	100,000
Public Information	200,000	200,000	200,000	200,000	200,000
Training	10,000	20,000	10,000	20,000	–
OPERATING					
Labor – State	3,700,000	5,500,000	800,000	800,000	1,300,000
– Contractor	–	–	2,700,000	4,100,000	–
– Garage	–	–	–	–	12,500,000
Equipment Maintenance	200,000	400,000	200,000	400,000	–
Public Information	300,000	300,000	300,000	300,000	300,000
Other Operating Costs	200,000	400,000	200,000	200,000	–

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*Details of cost elements in Appendix D.

(4) Summary of Fee Calculation

Table 17 illustrates the results of the fee calculation for the five program types. The sum of the average annualized capital investment and start-up cost and the average annualized operating cost (one-fifth of the life cycle operating cost) equals the total average annualized cost. This figure is divided by the average annual number of light duty vehicles to get an average annual fee per vehicle.

As shown in Table 17, the results indicate that in Kansas the State-operated program is the least expensive alternative; however, the contractor-operated program is only seven percent more expensive. The estimated annual fee per vehicle for a State-operated program would be $3.75 for an idle mode test and $5.50 for a loaded mode test. For a contractor-operated program the estimated annual fee for an idle test would be $4.00 and $5.75 for a loaded test. For the private garage-operated program, the estimated annual fee would be $6.75 for an idle test*. These costs represent an average over the five-year period, 1981 to 1985.

3. FINANCIAL FEASIBILITY

Kansas has the capability of financing vehicle inspection facilities. Three sources were considered for this funding, estimated at a maximum of $5.4 million. The most likely source is the State's general fund.[21] The fund is budgeted at $980 million for FY 79, and the $5.4 million required by the inspection program represents 0.5 percent of this program. While this percentage does not appear particularly significant itself, recent State legislation

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* The costs for the private garage operated programs were estimated at a fully loaded rate (hourly garage service rate). Although the current practice in many private garage operated safety inspection programs is for private garages to absorb some of the labor costs due to a perceived opportunity benefit of performing repairs on defective vehicles, it is not clear that this will continue for emissions inspections. Even if this were to be the case, this study compares actual costs of alternatives. Therefore, the full, actual costs are estimated and presented, regardless of whether they would be charged directly or passed on elsewhere.

TABLE 17
State of Kansas
Fee Calculation Summary
Current Dollars (Life Cycle 1981 - 1985)

	State– Operated		Contractor– Operated		Private Garage- Operated
	Idle	Loaded	Idle	Loaded	Idle
Annualized Capital And Start-up Cost					
State	$ 800,000	$1,300,000	$ 30,000	$ 30,000	$ 100,000
Contractor	–	–	800,000	1,200,000	–
Garage	–	–	–	–	200,000
Average Annual Operating Cost					
State	1,200,000	1,700,000	200,000	200,000	400,000
Contractor	–	–	900,000	1,300,000	–
Garage	–	–	–	–	3,200,000
Average Annual Contractor Profit	–	–	200,000	200,000	–
Total Average Annualized Cost					
State	2,000,000	3,000,000	230,000	230,000	500,000
Contractor	–	–	1,900,000	2,700,000	–
Garage	–	–	–	–	3,400,000
Average Annual Fee-Producing Vehicles	600,000	600,000	600,000	600,000	600,000
Average Annual Fee Per Vehicle					
State	$3.25	$5.00	$0.50	$0.50	$1.00
Contractor	–	–	3.25	4.50	–
Garage	–	–	–	–	5.75
TOTAL	$3.25	$5.00	$3.75	$5.00	$6.75

could seriously restrict the State as it attempts to finance vehicle inspection and other programs in years to come. The legislation which requires the State to assume local court costs and to provide ad valorem tax relief for the elderly, could place severe demands on the general fund in future years. As these programs develop and more local units of government and elderly citizens apply for and receive State funds, the conflicting demands of existing programs and future programs will be more evident.

While capital financing from the general fund does have several disadvantages, an even less likely source of capital is the State highway fund. State and Federal restrictions on the use of this fund presently eliminate it as a viable alternative for the automobile inspection program.[22] A cooperative effort being undertaken by the Department of Transportation and EPA could lead to the availability of these funds in the future.[23]

The final option available to Kansas is the issuance of long term debt. However, this is not a practical alternative in Kansas.[24] An amendment to the State Constitution is needed if the State is to incur additional general obligation debt, and the process of gaining voter approval for the amendment would not be cost-effective in this case. The issuance of revenue bonds, on the other hand, would require specific legislative authorization, and their issuance would also not be cost-effective in this case.[25]

In summary, Kansas has the capability to finance the capital requirements of the inspection program. The $5.4 million required is significant compared to the State's general fund, but it is not overwhelming (0.5 percent). The requirements are also small compared to the State's total personal income (0.2 percent). The disadvantages of the other alternatives indicate that the general fund is the most likely source of capital for this project.[26] A political decision would have to be made by the State Legislature to commit a portion of this fund to the inspection program.

4. EMISSIONS REDUCTION AND COST EFFECTIVENESS

As discussed in Chapter II, one of the major benefits of an I/M program is the emissions reduction that can be achieved through the periodic inspection of motor vehicles. A summary of these potential benefits for the non-attainment areas in Kansas (based on the MOBILE-1 computer program) is shown in Table 18. As shown, it is estimated that emissions reductions of up to 21.4 and 20.0 percent can be achieved for the metropolitan areas of Kansas City and Wichita respectively, by implementing an I/M program in these areas. This is regardless of the type of I/M program. It should be noted however, that the version of the MOBILE-1 program used for this analysis only evaluated the application of the I/M program to automobiles, whereas the I/M programs evaluated in this report also include light duty trucks. The potential reduction in hydrocarbon emissions from motor vehicles due to the I/M programs for the study areas would, therefore, be greater than the estimates given in Table 18. Furthermore, the potential reduction in motor vehicle emissions in the study area could be increased by increasing the stringency factor and/or by including heavy duty vehicles and motorcycles in the program. The choice of stringency factor and vehicle types subject to I/M would depend upon the amount of emissions reduction desired in the study areas.

Table 19 summarizes the results of the cost effectiveness analysis for the Kansas City and Wichita areas. Although the results of the cost effectiveness analysis do not yield additional information from a comparative perspective (they are directly related to the program cost results presented in Section 2), they can be compared to cost effectiveness results for other air quality programs.

5. OTHER SIGNIFICANT FACTORS FOR KANSAS

Four additional factors should be considered in the evaluation of alternative I/M programs for Kansas: current safety inspection, existing agencies with functions related to I/M, air quality laws, and consumer convenience. Each is discussed briefly below.

(1) Current Safety Inspection

In Kansas, automobile safety inspections are performed only upon change of ownership. These inspections are conducted by private garages for a uniform fee of $5.00, of which $.50 goes to the State and $4.50 is retained by the garage. The motorist receives an official certificate of approval when his vehicle passes the safety inspection.

TABLE 18
Projected Reduction in Non-Methane Hydrocarbons (NMHC) in Motor Vehicle Exhaust Due to I/M Implementation*

	JOHNSON & WYANDOTTE COUNTIES (Kansas City Area)	**SEDGWICK COUNTY** (Wichita Area)
Projected 1987 NMHC emissions without I/M (tons per year)	6,554	4,451
Projected 1987 NMHC emissions with I/M (tons per year)		
• Without mechanic training	5,724	3,848
• With mechanic training	5,151	3,556
Projected 1987 reduction in NMHC emissions due to I/M (tons per year)		
• Without mechanic training	830	603
• With mechanic training	1,403	894
Projected 1987 percentage reduction in NMHC due to I/M		
• Without mechanic training	12.65%	13.5%
• With mechanic training	21.4%	20.1%

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*Source: Kansas Department of Transportation.

TABLE 19
Summary of Cost Effectiveness Results

Program Type	1987 NMHC* Reduction (tons)	Projected 1987 I/M Program and Vehicle Repair Costs** (millions)	NMHC Reduction per Dollar Spent (pounds per dollar)
JOHNSON AND WYANDOTTE COUNTIES			
State-Operated			
Idle	1,403	$3.8	0.74
Loaded	1,403	4.6	0.61
Contractor-Operated			
Idle	1,403	4.1	0.68
Loaded	1,403	4.6	0.61
Private Garage-Operated	1,403	5.4	0.52
SEDGWICK COUNTY			
State-Operated			
Idle	894	$2.8	0.64
Loaded	894	3.3	0.54
Contractor-Operated			
Idle	894	2.9	0.62
Loaded	894	3.3	0.54
Private Garage-Operated	894	3.9	0.46

*Non-methane hydrocarbons

**See Appendix D for details

Since the current safety inspection is not annual, as the emissions inspection will be, the two inspections cannot be combined. It is not likely that the Kansas legislature will increase the safety requirements to an annual inspection since the change of ownership program was just recently instituted. A garage-based emissions inspection program could be administered in addition to the safety program where garages would perform safety and emissions inspections separately. This approach is being planned in at least one metropolitan area (Denver) and would not cause undue inconvenience to motor vehicle owners.

A centralized program could also be instituted to provide emissions testing. The current inspection program does not favor one I/M approach over the others.

(2) Kansas Agencies with Functions Related to I/M

Licensing and periodic inspection of private garages is presently handled by a staff of 20 troopers in the Kansas Highway Patrol. These troopers have been trained in automotive maintenance and garage equipment inspection. They check the garages for adequate testing equipment, space, and inspector certification. Since this same type of periodic inspection will form a part of quality assurance procedures for an I/M program, the presence of this Highway Patrol garage inspection unit could considerably facilitate I/M implementation. If garage inspection for I/M were placed under the direction of the Highway Patrol, some increase in staffing and additional training would be required.

Other State agencies which have functions related to an I/M program are the Department of Health and Environment and the Department of Revenue, as shown in Table 20. The Department of Health and Environment has responsibility for enforcing air quality requlations, and the Department of Revenue receives safety inspection certificates prior to vehicle registration. This existing infrastructure of organizations which support vehicle inspection in Kansas may ease the implementation of a decentralized I/M program, if this approach is selected. For the reason that it relieves State government of the operating responsibilities of emission inspection, the contractor-operated I/M program is expected to be the easiest to implement in Kansas.

TABLE 20
Existing Kansas State Agencies With
Functions Relevant to an I/M Program

Department	Division	Bureau	Functions
Health and Environment	Environment	Air Quality and Occupational Health	Enforce air quality regulations Analyze air quality data
Highway Patrol	Telecommunication Support Services	Motor Vehicle Inspection Administration	Inspect and certify garages for safety inspection Enforce safety inspection standards
Revenue	Vehicles	Titles and Registration	Maintain records on all vehicle registration Receive safety inspection certificates

(3) Kansas Air Quality Laws

Kansas presently has a law (Chapter 65, Article 30 of the Kansas Statutes) giving authority to the State Secretary of Health and Environment to provide rules and regulations for the control of emissions from motor vehicles. The article states that such rules and regulations may prescribe requirements for the installation and proper maintenance of emission control equipment. No provision is included for either the inspection of vehicles for emission levels or the enforcement of emission standards. Thus, existing Kansas laws will have to be amended by the State Legislature to include these fundamental provisions before any I/M program can be instituted.

(4) Consumer Convenience

The consumer convenience of I/M in Kansas will primarily be a function of the distance to the inspection station and the waiting time before testing. Although it is difficult to accurately predict waiting times for centralized and decentralized programs, a comparision can be made between the number of stations provided in each approach. From this comparison the difference in distance to a station may be inferred.

In Johnson and Wyandotte Counties it was estimated that there would be 60 times more inspection stations in a decentralized program than in a centralized program. A rough analysis indicates that on the average, a motorist would have to travel about eight times as far to get to a centralized station as to a decentralized station.

In Sedgwick County, there would be 48 times more inspections stations in a decentralized program than in a centralized program. A similar analysis to the one above indicates that a motorist in Sedgwick County would have to travel seven times as far to a centralized station as to a decentralized station.

In summary, a centralized program in Kansas will require motorists to travel seven to eight times the distance that would be required in a more convenient decentralized program

6. EVALUATION SUMMARY

This section summarizes the findings of the evaluation of I/M programs for Kansas and presents the conclusions based on these findings. A comparison of the I/M program alternatives is shown in Table 21. The table compares the following findings.

- The costs of the State and contractor-operated idle test program are comparable and are approximately 30 percent lower than the private garage-operated program.
- All programs are financially feasible since they are self-supporting.

TABLE 21
State of Kansas
Comparison of I/M Program Options

Program Type	Cost Per Vehicle	Average Cost Effectiveness (Pounds of Non Methane Hydrocarbons Reduced Per Dollar Spent)	Financial Feasibility	Ease Of Implementation	Consumer Convenience	Consumer Protection	Flexibility For Future Modification
STATE							
Idle	$3.25	0.70	Programs will be self-supporting; State capital investment needs are substantial ($3.0 to 5.4 million) but are small compared to State general fund.	**Low**: May face administrative constraints in hiring or curtailing staff and acquiring land, buildings and equipment.	**Low**: Limited number of central testing facilities requires travel for test and retest. Repair must be done elsewhere.	**High**: Quality of testing and repairs can be effectively controlled and monitored.	**High**: State has direct control over the entire program.
Loaded	5.00	0.58					
CONTRACTOR							
Idle	3.75	0.66	Programs will be self-supporting; no State capital investment needed.	**High**: Contractor can hire or curtail staff and acquire land, buildings, and equipment without administrative constraints. Relieves State of operating responsibility.	**Low**: Limited number of central testing facilities requires travel for test and retest. Repair must be done elsewhere.	**High**: Quality of testing and repairs can be effectively controlled and monitored.	**Medium**: Changes in program must be negotiated with the contractor.
Loaded	5.00	0.58					
PRIVATE GARAGE							
Idle	6.75	0.49	Program will be self-supporting; minor State capital investment needed.	**Medium**: Infrastructure of existing change of ownership safety inspection program would ease implementation, but State must still manage program.	**High**: Large number of garages distributed throughout the study areas for easy access. Provides opportunity for one stop test, repair, and retest.	**Low to Medium**: Depending upon the effectiveness of quality control measures for testing and repairs.	**Low**: State must deal with a large number of private garages to make changes effective.

- The infrastructure of the existing private garage-operated safety inspection program (change of ownership) will facilitate the implementation of an annual emission I/M program. The private garage and contractor approaches would require minor State investments, a small State staff and fewer administrative constraints than a State-operated program.

- Consumer convenience is high with the private garage approach because large numbers of garages can be certified to conduct the inspection providing easy access to motorists. A private garage also provides the opportunity for one-step test, repair, and retest. The centralized State- and contractor-operated programs place some travel requirements on persons not in the vicinity of the inspection station. If a vehicle does not pass the emissions test, it must be repaired in a garage or at home and then returned to the inspection station for a retest.

- Consumer protection is high for the centralized programs. The quality of inspection can be effectively controlled since a limited number of facilities are involved. The State- and contractor-operated program also provide an objective check on the effectiveness of repairs by monitoring the retests. The amount of consumer protection afforded by a private garage-operated program increases with the effectiveness of State quality control programs including certification of garages and inspectors, calibration checks, spot checks, and challenge garages, but would still be lower than that afforded by a centralized approach.

- Flexibility for future modification such as changing emission standards and equipment is high with the State-operated program since the State has direct control over the administration and operation of the program. The contractor approach has comparable flexibility, although changes may have to be negotiated with the contractor. Because of the large number of garages involved in the private garage-operated program, the flexibility for program modification is low since the changes must be simple enough to be uniformly implemented.

* * * *

It is clear from the comparison in Table 21 that none of the alternative I/M programs is the most preferred for all criteria. The selection of the most preferred program depends upon the relative importance of each of the evaluation criteria.

If the cost of the program to the motorist is considered as the only important criterion, then there would not be a significant difference between the State- and contractor-operated programs. The loaded test programs would be less desirable than the idle test programs.

Since the other criteria will likely play a significant role in determining the preferred option, each decision-maker must weigh the relative importance of the criteria in conjunction with the results of the evaluation before reaching a decision. If each of the criteria were given equal weight, then either the State- or contractor-operated idle test options would be desirable in Kansas.

VIII. EVALUATION OF I/M PROGRAMS FOR NEBRASKA

This chapter presents the results of the detailed evaluation conducted for the five I/M programs in the two Nebraska non-attainment areas (Douglas and Sarpy Counties). The first section describes the study area and identifies some of its key demographic and physical features. In the second section, the results of a detailed cost analysis of each of the five program types are presented. Section three analyzes the financial feasibility of the different programs based on capital requirements for the State. Section four presents the results of the cost effectiveness analysis, while section five summarizes the results of other significant issues investigated. Finally, section six summarizes the evaluations of the five program types and presents conclusions for Nebraska.

1. DESCRIPTION OF STUDY AREA

This study evaluated the prospect of alternative vehicle emissions inspection/maintenance programs in Douglas and Sarpy Counties, Nebraska. These counties are situated on the Missouri River at the eastern end of the State and include the metropolitan area of Omaha as shown in Figure 8. Table 22 describes some of the key demographic and physical features of this area.

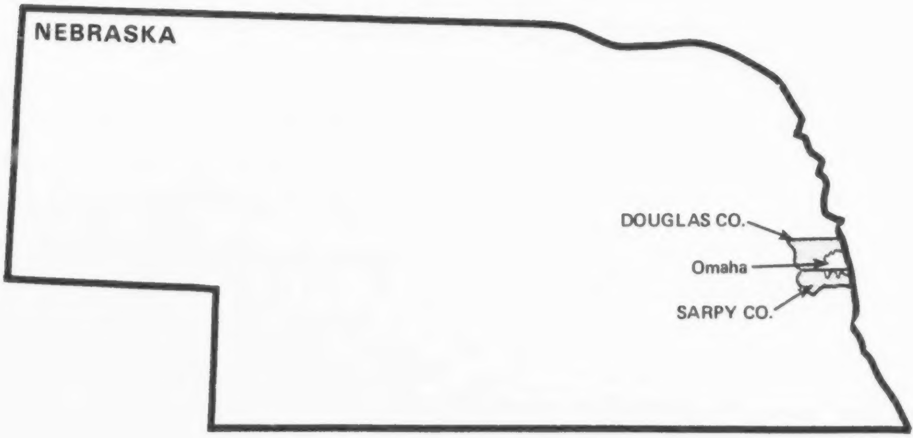

FIGURE 8
Map of Nebraska Study Area

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TABLE 22
Key Features of Douglas and
Sarpy Counties, Nebraska

DOUGLAS AND SARPY COUNTIES (Omaha)	
Population:	453,444
Area:	1487 square kilometers (574 square miles)
Population Density:	305 persons per square kilometer (790 persons per square mile)
1977 Registered Light Duty Vehicles:	300,000

2. COST ANALYSIS RESULTS

This section presents the results of the life cycle cost analysis for the five I/M program options in Nebraska. Although costs were estimated for the specific requirements of each non-attainment area, only the total life cycle costs and inspection fees are shown. All costs are estimated for a life cycle of five years, 1981 to 1985, and are referred to in the report as "current" dollars.* Several assumptions however were necessary to estimate costs in the study (e.g., level of inspection automation, number of employees in program administration, and the average inflation rate over the period 1978 to 1985). As a result, actual program costs may vary from the cost estimates presented herein depending upon the actual program design.

The section is divided into four parts, as follows:

- Summary of capital investment, startup, and operating costs
- Summary of costs to the State
- Summary of life cycle costs
- Summary of fee calculation

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*Current dollars is an economic term used to denote actual dollar values at a particular point in time.

(1) Summary of Capital Investment, Startup and Operating Costs

Table 23 identifies the major cost results from the analysis. Capital investments and start-up costs vary from $1.5 to $3.2 million depending on the type of program (centralized or private garage). The centralized programs require 1.4 times the capital investment of the private garage program for the idle test. Conversely, the private garage program has 1.7 times the annual operating costs of the centralized program for an idle mode test. Overall, the private garage program is 30 percent more costly than the centralized programs. The loaded mode test is 40 percent more costly than the idle mode test.

TABLE 23
State of Nebraska
SUMMARY OF COST ANALYSIS RESULTS
Current Dollars (Life Cycle 1981-1985)

Program Type	Initial Capital Investments and Start-Up Costs	Average Annual Operating Costs	Total Average Annualized Costs
State Operated			
Idle	$2,100,000	$ 900,000	$1,400,000
Loaded	3,200,000	1,200,000	2,000,000
Contractor Operated			
Idle	2,100,000	900,000	1,500,000
Loaded	3,200,000	1,100,000	2,000,000
Private Garage Operated			
Idle	1,500,000	1,500,000	1,900,000

(2) Summary of Costs to the State

Table 24 summarizes the cost to the States of the different I/M program options. Capital investments for State-operated programs are $1.6 million for the idle test and $2.7 million for the loaded test. State startup costs vary from $100,000 to $500,000. The State's involvement in the contractor program is minimal (11 to 14 percent of the cost). For the private garages, however, the involvement is slightly higher (18 percent of the cost). The number of State employees varies from eight in the contractor program to 58 in the State-operated program. The private garage program has eight employees, a significant number of them taking responsibility for program enforcement. The private garage program employees are assumed to be in addition to the existing motor vehicle safety inspection program staff.

TABLE 24
State of Nebraska
SUMMARY OF COSTS TO THE STATE
Current Dollars (Life Cycle 1981-1985)

Program Type	Initial State Capital Investments	Initial State Start-Up Costs	Average Annual State Operating Costs	State Costs as Percent of Total Program Cost	Number of State Employees
State Operated					
Idle	$1,600,000	$500,000	$ 900,000	100%	40
Loaded	2,700,000	500,000	1,200,000	100	58
Contractor Operated					
Idle	0	100,000	200,000	14	8
Loaded	0	100,000	200,000	11	8
Private Garage Operated					
Idle	2,000	400,000	200,000	18	8

(3) Summary of Life Cycle Costs

Table 25 presents the estimates for system costs over the 1981 to 1985 life cycle of the programs. All of the costs are given in 1978 dollars. The costs are separated into three categories: capital investments, start-up, and operating. Both the capital investments and the start-up costs are incurred in the year preceding the program start date. The operating costs are estimated over the program life cycle. Details of the assumptions and calculations for these data are given in Appendix D.

TABLE 25
State of Nebraska
FIVE YEAR LIFE CYCLE COST ELEMENT SUMMARY
(1978 Dollars)

Cost Element*	State-Operated		Contractor-Operated		Private Garage Operated
	Idle	Loaded	Idle	Loaded	Idle
CAPITAL					
Building	$600,000	$1,100,000	$ 600,000	$1,100,000	–
Land	200,000	300,000	200,000	300,000	–
Equipment – State	600,000	900,000	–	–	$ 2,000
– Contractor	–	–	600,000	900,000	–
– Garage	–	–	–	–	1,000,000
START-UP					
Labor – State	200,000	200,000	100,000	100,000	100,000
– Contractor	–	–	100,000	100,000	–
Program Design	100,000	100,000	100,000	100,000	100,000
Public Information	100,000	100,000	100,000	100,000	100,000
Training	10,000	20,000	10,000	20,000	–
OPERATING					
Labor – State	2,800,000	3,900,000	800,000	800,000	600,000
– Contractor	–	–	2,100,000	2,900,000	–
– Garage	–	–	–	–	5,000,000
Equipment Maintenance	200,000	300,000	200,000	300,000	–
Public Information	200,000	200,000	200,000	200,000	200,000
Other Operating Costs	200,000	300,000	200,000	300,000	–

*Details of cost elements in Appendix D.

(4) Summary of Fee Calculation

Table 26 illustrates the results of the fee calculation for the five program types. The sum of the average annualized capital investment and start-up costs and the average annualized operating cost (one-fifth of the life cycle operating cost) equals the total average annualized cost. This figure is divided by the average annual number of light duty vehicles to get an average annual fee per vehicle.

As shown in Table 26, the results indicate that in Nebraska, the State-operated program would be the least expensive alternative; however, the contractor-operated program would be only eight percent more expensive. The estimated annual fee per vehicle for a State-operated program, would be $3.00 for an idle mode test and $4.50 for a loaded mode test. For a contractor-operated program, the estimated annual fee for an idle test would be $3.50 and $4.50 for a loaded test. For private garage-operated programs, the estimated annual fee would be $4.25 for an idle test.* It was assumed for this analysis that the private garage inspection fee would be incorporated into the annual safety inspection fee.** These costs represent an average over the five-year period, 1981 to 1985.

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*The costs for the private garage-operated programs were estimated at a fully loaded rate (hourly garage service rate). Although the current practice in many private garage-operated safety inspection programs is for private garages to absorb some of the labor costs due to a perceived opportunity benefit of performing repairs on defective vehicles, it is not clear that this will continue for emissions inspections. Even if this was to be the case, this study compares actual costs of alternatives. Therefore, the full, actual costs are estimated and presented, regardless of whether they would be charged directly or passed on elsewhere.

**In neighboring Pottawattamie County, Iowa (Council Bluffs), there is no annual safety inspection program. For this reason the labor costs for the Council Bluffs private garage-operated program were substantially higher since the emissions inspection will be a separate program. In Nebraska, the emissions inspection activity was considered as an additional component of the existing program.

TABLE 26
State of Nebraska
FEE CALCULATION SUMMARY
Current Dollars (Life Cycle 1981-1985)

	State-Operated		Contractor-Operated		Private Garage-Operated
	Idle	Loaded	Idle	Loaded	Idle
Annualized Capital and Start-up Cost					
State	$ 500,000	$ 800,000	$ 30,000	$ 30,000	$ 100,000
Contractor	–	–	500,000	700,000	–
Garage	–	–	–	–	300,000
Average Annual Operating Cost					
State	900,000	1,200,000	200,000	200,000	200,000
Contractor	–	–	700,000	900,000	–
Garage	–	–	–	–	1,300,000
Average Annual Contractor Profit	–	–	100,000	200,000	–
Total Average Annualized Cost					
State	1,400,000	2,000,000	230,000	230,000	300,000
Contractor	–	–	1,300,000	1,800,000	–
Garage	–	–	–	–	1,600,000
Average Annual Fee-Producing Vehicles	450,000	450,000	450,000	450,000	450,000
Average Annual Fee Per Vehicle					
State	$3.00	$4.50	$0.50	$0.50	$0.75
Contractor	–	–	3.00	4.00	–
Garage	–	–	–	–	3.50
	$3.00	$4.50	$3.50	$4.50	$4.25

3. FINANCIAL FEASIBILITY

Nebraska has the capability of financing vehicle inspection facilities. Capital needs for the State, estimated at a maximum of $2.7 million, could be made available from one of four possible sources. The most likely source is the State's general fund which is budgeted at $.5 billion for FY 1979.[27] The fund is not likely to grow more than five percent per year during the next four years because of the announced intentions of the State legislature and the pronouncements of the two candidates in this Fall's gubernatorial election. The approximately $2.7 million required by the inspection program is 0.5 percent of the 1979 budget.

A less likely source of capital is the State's cigarette tax fund.[28] In 1972, the tax which supports this fund was increased 63 percent for the specific purpose of financing the State's use of office buildings. The fund is totally committed at the present time, and it is not likely that the tax would be increased again in the near future.[29] Thus, this fund is not a likely source of capital for the automobile inspection program. Another possible source of capital could be the Nebraska Highway Fund, but State and Federal restrictions on its use presently eliminate it as a viable alternative for the inspection program.[30] A cooperative effort being undertaken by the Department of Transportation and EPA could lead to the availability of these funds in the future.[31]

The final option available to the State is the issuance of long-term debt. This is not a practical alternative in Nebraska.[32] An amendment to the State Constitution is needed if the State is to incur either general obligation or revenue bonding debt, and the process of gaining voter approval for the amendment would not be cost-effective in this case.[33]

In summary, Nebraska has the capability to finance the capital requirements of the inspection program. The $2.7 million requirement is not small compared to the State's general fund (0.5 percent), but neither is it excessive The requirements are, however, small compared to the State's total personal income (0.03 percent). The disadvantages of the other possible alternatives indicate that the general fund is the most likely source of capital for this project.[34] A political decision would have to be made by the State legislature to commit a portion of this fund to the inspection program.

4. EMISSIONS REDUCTION AND COST EFFECTIVENESS

As discussed in Chapter II, one of the major benefits of an I/M program is the emissions reduction that can be achieved through the periodic inspection of motor vehicles. A summary of these potential benefits for the non-attainment area in Nebraska (based on the Mobile-1 computer program) is shown in Table 27. As shown, it is estimated that emissions reductions of up to 20.7 percent can be achieved for the Omaha metropolitan area by implementing an I/M program in this area. This is regardless of the type of I/M program.

It should be noted that the version of the Mobile-1 program used for this analysis only evaluated the application of the I/M program to automobiles, whereas the I/M programs evaluated in this report also include light duty trucks. The potential reduction in hydrocarbon emissions from motor vehicles due to the I/M programs for the study areas would, therefore, be greater than the estimates given in Table 27. Furthermore, the potential reduction in motor vehicle emissions in the study area could be increased by raising the stringency factor and/or including heavy duty vehicles and motorcycles in the program. The choice of stringency factor and vehicle types subject to I/M would depend upon the amount of emissions reduction desired in the study areas.

Table 28 summarizes the results of the cost effectiveness analysis for the Omaha area. Although the results of the cost effectiveness analysis do not yield additional information from a comparative perspective (they are directly related to program cost results presented in Section 2), they can be compared to cost effectiveness results for other air quality programs.

5. OTHER SIGNIFICANT FACTORS FOR NEBRASKA

In addition to cost and financial feasibility, the most significant factor affecting the evaluation of alternative I/M programs for Nebraska is the existing periodic safety inspection. Other important factors are government agencies with functions relevant to an I/M program, the air pollution control laws and consumer convenience. Each factor is discussed below.

TABLE 27
Projected Reduction in Non-Methane Hydrocarbons (NMHC) in Motor Vehicle Exhaust Due to I/M Implementation

	DOUGLAS & SARPY COUNTIES (OMAHA)
Projected 1987 NMHC emissions without I/M* (tons per year)	6,394
Projected 1987 NMHC emissions with I/M** (tons per year)	
• Without mechanic training	5,556
• With mechanic training	5,070
Projected 1987 NMHC reduction due to I/M (tons per year)	
• Without mechanic training	838
• With mechanic training	1,324
Projected 1987 NMHC reduction due to I/M	
• Without mechanic training	13.1%
• With mechanic training	20.7%

*Source: Iowa Department of Transportation.

**Projection based on similar results for Kansas. Nebraska results were not available at time of publication.

TABLE 28
Summary of Cost Effectiveness Results

Program Type	1987 NMHC* Reduction (tons)	Projected 1987 I/M Program and Vehicle Repair Costs** (millions)	NMHC Reduction per Dollar Spent (pounds per dollar)
DOUGLAS AND SARPY COUNTIES			
STATE-OPERATED			
Idle	1,324	$4.0	0.66
Loaded	1,324	4.8	0.55
CONTRACTOR-OPERATED			
Idle	1,324	4.3	0.62
Loaded	1,324	4.8	0.55
PRIVATE GARAGE-OPERATED	1,324	4.6	0.58

*Non-methane hydrocarbons

**See Appendix D for details

(1) Periodic Safety Inspection

In Nebraska, automobile safety inspections are administered annually by the Department of Motor Vehicles. The inspections are conducted in over 2,000 certified private garages throughout the State. Each inspection takes approximately 30 minutes and the uniform fee is $3.75. Forty cents out of the fee is paid to the State to defray the cost of program administration, inspector certification and program enforcement, which is sufficient to make the program self-supporting.

Since motor vehicle safety inspections are currently administered annually by certified garages in Nebraska, and the emissions program will also be an annual program, the favored approach for ease of implementation of an emissions I/M program would be to add it to the existing safety inspection. It is expected that public inconvenience and some administrative inefficiency may result if safety inspections were conducted by private garages and emissions inspections were conducted by State or contractor-operated facilities.

(2) State Agencies With Functions Relevant to an I/M Program

Several State agencies in Nebraska currently perform functions relevant to an emissions I/M program. As shown in Table 29, the Departments of Environmental Control and Motor Vehicles perform the functions of enforcing air quality standards and certifying safety inspection standards. Proposed legislation relating to the powers of the Department of Environmental Control authorizes, in addition, emissions inspection and motor vehicle emissions standards enforcement. The presence of a Motor Vehicle Safety Inspection Agency increases the expected ease of implementation for a decentralized I/M program.

(3) Air Pollution Control Laws

The State of Nebraska currently does not have legislative authority for the control of air pollution from motor vehicles. Legislation relating to the powers and duties of the Department of Environmental Control

TABLE 29
Existing Nebraska State Agencies With Functions Relevant to an I/M Program

Department	Division	Functions
Environmental Control	Air Pollution Control	Analyze air quality data Enforce air quality standards
Motor Vehicles	Motor Vehicle Safety Inspection	Certify safety inspection stations Enforce safety inspection standards Train certified private garage inspectors

(DEC) does not specify the regulation of motor vehicle emissions, and legislation relative to the Department of Motor Vehicles specifies only the requirement for safety inspections. Legislation has been drafted to amend these statutes to include periodic emissions testing of motor vehicles. When enacted, it will give the State specific authority to establish a motor vehicle emissions I/M program and authorize the Department of Motor Vehicles to monitor and enforce the standards. The laws do not favor one I/M approach over another.

(4) Consumer Convenience

Consumer convenience of I/M in Nebraska is a function of the distance to inspection stations and the waiting time for a test. It is difficult to accurately predict waiting times for centralized and decentralized programs, but a comparison can be made between the number of inspection stations required for each approach. From this comparison an analysis of consumer convenience can be made.

In Douglas and Sarpy Counties it is estimated that there will be 110 times more inspection stations in a decentralized program than in a centralized program (440 decentralized stations versus 4 centralized). A rough analysis indicates that on the average, a motorist would have to travel about eleven times further to get to a centralized station. The decentralized approach thus offers greater consumer convenience to Nebraska motorists.

6. EVALUATION SUMMARY

This section summarizes the findings of the evaluation of I/M programs for Nebraska and presents the conclusions based on these findings. A comparison of the five I/M program alternatives which were analyzed in detail is shown in Table 30. A summary of the program based on this table is as follows:

- The costs of the State- and contractor-operated programs are comparable. The private garage-operated program is 30 percent more costly than the State-operated program.

TABLE 30
Comparison of I/M Program Options for Nebraska

Program Type	Cost Per Vehicle	Average Cost Effectiveness (Pounds of Non-Methane Hydrocarbons Reduced Per Dollar Spent)	Financial Feasibility	Ease Of Implementation	Consumer Convenience	Consumer Protection	Flexibility For Future Modification
STATE							
Idle	$3.00	0.66	Programs will be self-supporting. State capital investment needs are substantial ($1.6 to $2.7 million) but are small compared to State general fund.	**Low**: May face administrative delays in hiring or curtailing staff and acquiring land, buildings and equipment.	**Low**: Limited number of central testing facilities requires travel for test and retest. Repair must be done elsewhere.	**High**: Quality of testing and repairs can be effectively controlled and monitored.	**High**: State has direct control over the entire program.
Loaded	4.50	0.55					
CONTRACTOR							
Idle	3.50	0.62	Programs will be self-supporting; no State capital investment needed.	**Medium**: Contractor can hire or curtail staff and acquire land, buildings, and equipment without administrative delays.	**Low**: Limited number of central testing facilities requires travel for test and retest. Repair must be done elsewhere.	**High**: Quality of testing and repairs can be effectively controlled and monitored.	**Medium**: Changes in program must be negotiated with the contractor.
Loaded	4.75	0.55					
PRIVATE GARAGE							
Idle	4.25	0.58	Program will be self-supporting, minor State capital investment needed.	**High**: Annual emissions inspection can be easily added to the existing annual safety inspection program.	**High**: Large number of garages distributed throughout the study areas for easy access. Provides opportunity for one stop test, repair, and retest.	**Low to Medium**: Depending upon the effectiveness of quality control measures for testing and repairs.	**Low**: State must deal with a large number of private garages to make changes effective.

- The costs of the State- and contractor-operated loaded test programs are approximately 40 percent higher than corresponding idle test programs.

- All programs are financially feasible since they will be self-supporting. A political decision to allocate a portion of the State General Fund to meet the capital investment needs of the State-operated program must be made by the legislature.

- Since an annual private garage-operated safety inspection program already exists in Nebraska, an emissions test could be incorporated into the safety inspection. Implementation of a contractor-operated program would be more difficult due to complex negotiations that would be required between the State and contractor. The State-operated program is the most difficult to implement due to administrative delays that may be encountered in hiring staff and acquiring land, buildings, and equipment.

- Consumer convenience is high with the private garage approach because a large number of garages can be certified to perform the testing. A private garage also provides an opportunity for one-stop test, repair, and retest. The centralized State- and contractor-operated programs, on the other hand, place some travel requirements on persons not in the vicinity of the inspection station. If a vehicle fails the emission test, it must be repaired in a garage or at home and taken again to the inspection station for a retest.

- Consumer protection is high with the centralized programs. The quality of inspection can be effectively controlled since a limited number of facilities are involved. The State and contractor-operated programs also provide an objective check on the quality of repairs performed by the repair industry by monitoring vehicles requiring a retest. The degree of consumer protection afforded by a private garage-operated program increases with the effectiveness of State quality control programs such as certification of garages and inspectors, calibration checks, spot checks and challenge garages, but is still lower than that afforded by the State or contractor approach.

- Flexibility for future modification such as adjustments in emission standards and equipment is high with the State-operated program since the State has direct control over the administration and operation of the program. The contractor approach has comparable flexibility, except that changes may have to be negotiated with the contractor. Because of the large number of garages involved in the private garage-operated program, the flexibility for program modification is low since the changes must be simple enough to be uniformly implemented.

* * * * * *

It is clear from the comparison in Table 30 that none of the alternative I/M programs are the most preferred for all criteria. The selection of the most preferred program depends upon the relative importance of each of the evaluative criteria.

If the cost of the program to the motorist is considered as the only important criteria, then the State- and contractor-operated programs would be preferred over the decentralized approach. The loaded mode test would be less desirable than the idle test programs.

Since the other criteria will likely play a significant role in determining the preferred option, each decision-maker must weigh the relative importance of the criteria in conjunction with the results of the evaluation before reaching a decision. If the criteria were given equal weight, then the private garage-operated program would be the most desirable in Nebraska primarily due to its ease of implementation and consumer convenience.

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APPENDIX A
METHODOLOGY FOR ANALYZING COSTS OF ALTERNATIVE INSPECTION/MAINTENANCE PROGRAMS

APPENDIX A

METHODOLOGY FOR ANALYZING COSTS OF ALTERNATIVE INSPECTION/MAINTENANCE PROGRAMS

This appendix describes the general methodology employed for determining the inspection fee associated with alternative inspection/maintenance (I/M) programs described in Chapters VI, VII and VIII. This appendix contains the following information:

- A summary of the computational procedures employed in determining the inspection fee
- A summary of the analytical assumptions including the rationale for making the assumptions
- A summary of the analysis outputs.

The data and specific equations used in computing the costs are outlined in Appendix D. This appendix only describes the general methodology.

1. OVERVIEW OF APPROACH

The basic approach presented is based on the concept of life cycle costs. This means that all expenditures associated with the development, implementation, and operation of the proposed I/M program over the life of the program are considered in determining the inspection fee. An overview of this approach is shown in Figure A-1.

As shown in the figure, calculation of the inspection fee for the proposed program is determined by:

- First, calculating the life cycle costs associated with the State's, contractor's, and/or private garages' involvement with the program
- Second, combining the life cycle costs computed for the State, contractor, and/or the private garages to determine total program life cycle costs
- Third, calculating the number of vehicles which would be subject to inspection over the life of the program.

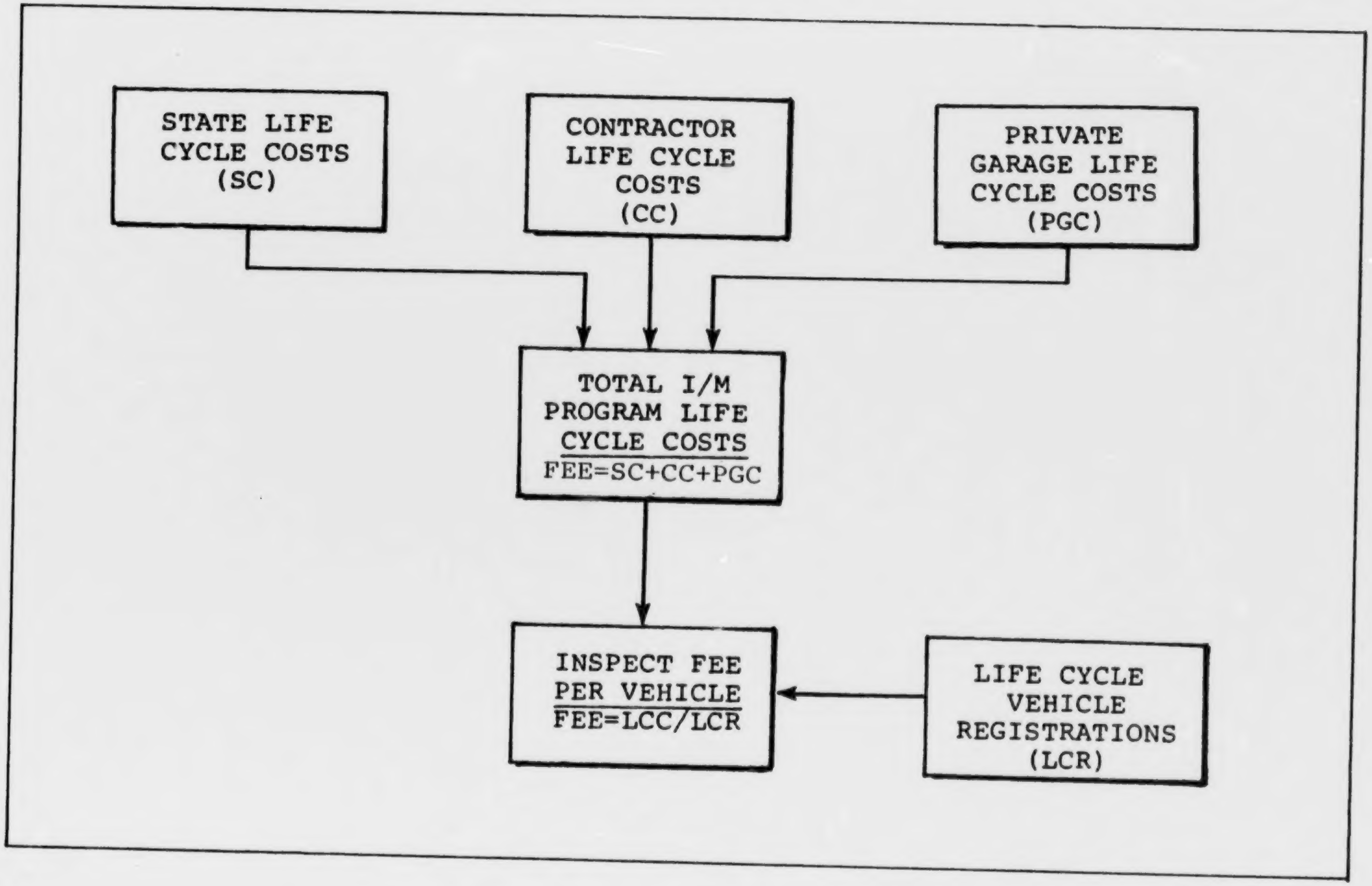
STATE LIFE CYCLE COSTS (SC)
CONTRACTOR LIFE CYCLE COSTS (CC)
PRIVATE GARAGE LIFE CYCLE COSTS (PGC)
TOTAL I/M PROGRAM LIFE CYCLE COSTS
FEE=SC+CC+PGC
INSPECT FEE PER VEHICLE
FEE=LCC/LCR
LIFE CYCLE VEHICLE REGISTRATIONS (LCR)

Figure A-1
Overview of Approach for
Determining Inspection Fee

The inspection fee per vehicle is determined by dividing the total program life cycle costs by the total number of vehicles inspected over the life of the program. The methods for calculating total program life cycle costs and life cycle vehicle registration are presented in the following sections.

2. METHODOLOGY FOR CALCULATING I/M PROGRAM LIFE CYCLE COSTS

Life cycle costs are normally determined by adding the maintenance and operating costs each year to the yearly investment cost (interest plus amortization payment of the initial cost) and then totalling these for the life of the program. In lieu of this procedure, however, it is convenient to first calculate the individual life cycle cost for each component of total cost, and then to total these in order to determine the total life cycle cost. It is this latter procedure which is proposed and which is described in this section. The basic life cycle cost equation is as follows:

$$\text{Life Cycle Costs} = ICC + SUC + OCC$$

where:
ICC = Life cycle investment costs
SUC = Life cycle start-up costs
OCC = Life cycle operating costs

(1) Investment Costs

Life cycle investment costs are the initial outlay of capital investments associated with an I/M program plus the interest paid on the money borrowed to finance these costs. Initial investments usually include the construction of buildings/facilities and the purchase of equipment.

Life cycle investment costs are determined by multiplying the intial investments (K) by the product of program life (n) and a factor which amortizes the initial costs over the life of the program (Y). The factor Y is derived by assuming that the required capital is borrowed at the beginning of the first year of the program's life, and repaid in equal yearly principal and interest payments throughout the life of the program. The formula used to compute life cycle investment costs is as follows:

Life Cycle Investment Costs = $K \cdot n \cdot Y$

where:
K = Total initial capital investment
n = Life of the program
Y = Yearly principal and interest cost on one dollar, equal to:

$$\frac{i(1+i)^n}{(1+i)^n - 1}$$

where i equals the interest rate and n equals the life of the program

(2) Start-up Costs

Life cycle start-up costs are those costs, other than the initial investment costs described above, necessary to establish the program, plus (as with initial investment costs) the interest paid on the money borrowed to finance these costs. Included are such costs as:

- Program Design Costs - Contractor support to the State for actual design of the system
- Public Information Costs - Costs of the initial stages of public information program, i.e., media campaign to inform the public about the program, information seminars for repair establishment management, and administration of a consumer affairs office
- Inspector/Mechanic Training Costs - Costs associated with organization of the training program, of supplies (i.e., books) and the initial training of inspectors/mechanics.

Life cycle start-up costs are computed in the same manner as investment costs. Namely, as follows:

Life Cycle Start-Up Costs = $S \cdot n \cdot Y$

where:
S = Total start-up costs
n = Life of the program
Y = Yearly principal and interest cost on one dollar, equal to:

APPENDIX B
THROUGHPUT CALCULATION

APPENDIX B

THROUGHPUT CALCULATION

This appendix explains the assumptions and logic which were used in estimating the throughput capacity of idle and loaded mode centralized inspection lanes.

1. DEFINITION OF VEHICLE THROUGHPUT

Vehicle throughput refers to the number of vehicles which may be processed through an inspection lane in a given time period. It is measured by observing the exact amount of time required to perform the necessary testing procedures on a single vehicle, and then estimating the total vehicles which can be processed during an hour, day or year as a function of the observed testing time. The vehicle throughput capacity of an inspection lane is a fundamental assumption in the development of cost estimates for idle and loaded mode centralized I/M facilities.

2. METHODOLOGY FOR CALCULATING VEHICLE THROUGHPUT

Detailed time and motion study and throughput data have not been collected for many I/M programs. Throughput data were requested from the larger I/M programs; however, where quantitative information was not available, estimates based on personal experience were substituted. The following programs contributed the throughput information summarized in Table B-1:

- Portland
- Arizona
- Chicago
- Cincinnati
- New Jersey.

While there are some consistencies among the data from different programs, each program has unique operating features which affect the throughput capability of the lanes. Thus, different throughput rates are observed in each program. Some of the operating features which affect throughput are:

TABLE B-1

Summary Of Vehicle Throughput By Program

LOCATION	PROGRAM DESCRIPTION	VEHICLES PER HOUR		EFFICIENCY*
		THEORETICAL THROUGHPUT	OBSERVED THROUGHPUT	
Portland	State-operated idle mode test using tachometer -- manual data handling (also tampering check)	40	20 - 25	50 - 63%
Chicago	City-operated idle mode test using tachometer -- automated data handling (no tampering check)	40	10 - 13	25 - 33%
Arizona	Contractor operated loaded mode test -- automated data handling	34	20 - 22	61 - 65%
Cincinnati	City-operated idle mode test plus safety (no tachometer) manual data handling	60	30 - 36	50 - 60%
New Jersey	State-operated idle mode test plus safety (no tachometer) manual data handling	54	30 - 35	58 - 67%

*Average efficiency: 49 - 58%
Midpoint: 53.5%

- Test mode: Idle versus loaded
- Test procedure: Idle using a tachometer versus idle without a tachometer*
- Amount of data collected: Some programs collect more detailed information than others
- Tampering check: In Oregon, a visual examination of positive crankcase ventilation, exhaust gas recirculation and evaporative control systems is made after the inspector lifts the hood and before the tachometer is attached.

Given the variations in testing time and throughput which result from different operating features, some assumptions must be made to estimate throughput for evaluating alternative programs in Region VII. Figure B-1 shows the basic facility layout assumed for this evaluation. The inspection process entails three functions: data collection, emissions test, and communication of results

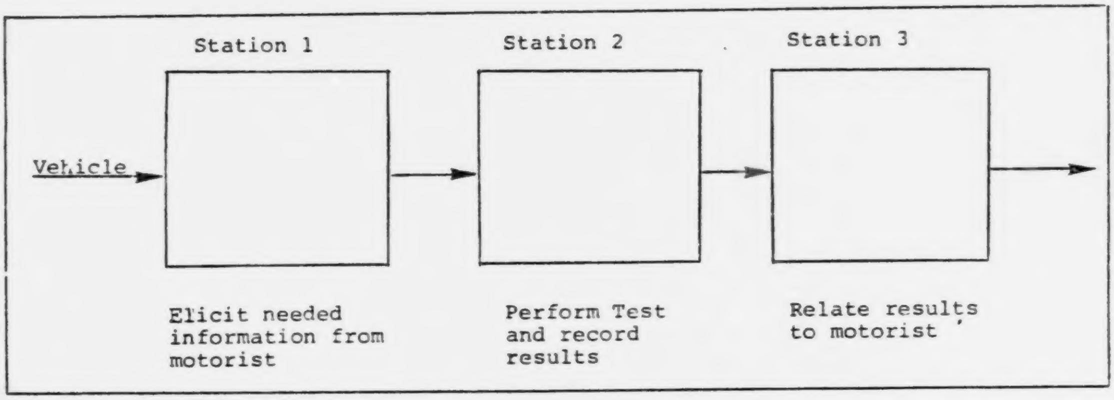
Station 1
Station 2
Station 3
Vehicle
Elicit needed information from motorist
Perform Test and record results
Relate results to motorist

FIGURE B-1
Basic Station Layout

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* A tachometer is manually attached to the spark plug wire to measure engine rpm's. Through use of a tachometer the vehicle can be tested at different idle speeds, such as 2200 or 2500 rpm's. This procedure reduces vehicle throughput since the inspector must raise the hood and attach the tachometer before the test is run.

to the motorist. To estimate the throughput capacity of this assumed layout, time and motion data for existing programs were analyzed. Table B-2 summarizes some time study data from the New Jersey* and Arizona programs.

TABLE B-2
Time and Motion Data for Emissions Inspection

Station Number	Inspection Function	Time to Perform Inspection Function	
		New Jersey	Arizona
1	Data Collection	40 seconds (manual)	45 seconds (automated)
2	Emissions Test	20 seconds (idle)	115 seconds (loaded)
3	Result	60 seconds (manual)	60 seconds (automated)

From the time and motion data presented above, the following observations can be made:

- In New Jersey, where an idle test is used, vehicle throughput is dominated by the last station. Theoretically, this program can process one vehicle every 60 seconds or 60 vehicles per hour.
- In Arizona, where a loaded test is used, vehicle throughput is dominated by the test itself. Theoretically, this program can process one vehicle every 115 seconds, or 31 vehicles per hour.

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* Although New Jersey has a combined safety and emissions inspection, detailed time and motion studies performed by Booz, Allen identified the exact amount of time required for each inspection function independent of the other testing activities.

- The time required for Stations 1 and 3, data collection and communication of results to the motorist, are the same for both programs (40 to 45 seconds for Station 1 and 60 seconds for Station 3). This is surprising in view of the fact that the New Jersey program uses manual data handling procedures and Arizona's program is automated. Thus, on the basis of this data the use of automated data collection procedures does not increase vehicle throughput.

The information developed thus far may now be converted to annual expected throughput by assuming:

- 53.5 percent efficiency (calculated from Table B-1)

- 2500 hours of station operation (250 days X 10 hours per day).

The efficiency factor accounts for natural fluctuations in the facility's vehicle handlings. Decreases in vehicle handlings occur when there are no vehicles waiting in line to be tested, when the inspection staff is temporarily reduced (work breaks, illness, vacation), or during tie-ups in the flow of vehicles through the lanes (stalled vehicle, misplaced vehicle identification, poor weather). The assumed station operating hours (2500) are modeled after the operating hours of existing I/M programs.

Vehicle throughput is calculated as follows:

Vehicle Throughput	=	Number of Vehicles/Hr.	X	Number of Operating Hrs.	X	Efficiency Factor
Vehicle Throughput (Idle)	=	60	X	2500	X	53.5%
Vehicle Throughput (Loaded)	=	31	X	2500	X	53.5%

3. RESULTS

The results of the vehicle throughput calculations are shown in Table B-3.

TABLE B-3

Expected Vehicle Throughput For
Contractor Or State Operated Inspection Program

Test Mode	Vehicles per Lane per Year	
	Manual	Automated
Idle	80,000	80,000
Loaded	42,000	42,000

Based on the results of the throughput calculation, the cost analysis for a centalized I/M program (see Appendix A) is based on a vehicle throughput capacity of 80,000 vehicles for an idle test and 42,000 vehicles for a loaded test. No difference in throughput is attributed to the type of data handling, as long as the amount of initial data collected is comparable.

APPENDIX C

VEHICLE POPULATION AND INSPECTION FACILITY REQUIREMENTS

APPENDIX C

VEHICLE POPULATION AND INSPECTION FACILITY REQUIREMENTS

This section describes the following calculations of projected vehicle population and inspection facility requirements:

- Calculation of life cycle vehicles by study area
- Summary of inspection facility requirements for Iowa, Kansas and Nebraska

1. CALCULATION OF LIFE CYCLE VEHICLES BY STUDY AREA

Table C-1 describes the calculation of the life cycle vehicles by study area. The calculation is based on a historical growth projection of the 1977 light duty vehicle population. The result of this calculation is the average annual fee producing vehicles during the 1981-1985 life cycle. This result is used in the calculation of the annual inspection fee per vehicle.

2. SUMMARY OF INSPECTION FACILITY REQUIREMENTS FOR IOWA, KANSAS AND NEBRASKA

(1) Iowa

The data in Table C-2 were used to calculate the number of inspection lanes and facilities required in each program area. Data for these calculations were obtained from the Iowa Department of Transportation.

For the centralized programs, the results indicate that Polk County (Des Moines) will require five centralized idle mode test lanes and nine lanes for the centralized loaded mode test. These results were obtained by dividing the projected number of inspections in 1985 (the constraining year for the five-year life cycle) by 80,000 inspections per year per lane for idle and 42,000 inspections per year per lane for loaded. These figures are the estimated throughputs for the two types

TABLE C-1
Calculation of Life Cycle Vehicles by Study Area

PROGRAM AREA	(V) 1977 LDV Population	(a) Estimated Growth Rate To 1985	(b) Annual Growth Rate $\left[(1+a)^{\frac{1}{8}}\right]-1$	(c) Life Cycle Vehicles in Program $\sum_{i=4}^{8} V(1+b)^{i}$	Average Annual Fee Producing Vehicles C ÷ 5
Kansas City	279,951	+18%	+2.1%	1,586,000	317,000
Wichita	234,429	+15%	+1.8%	1,305,000	261,000
Kansas Total	514,380			2,891,000	578,000
Des Moines	223,613	+27%	+3.0%	1,336,000	267,200
Council Bluffs	63,112	+19%	+2.2%	360,000	71,900
Davenport	111,956	+29%	+3.2%	677,000	135,400
Iowa Total	398,681			2,373,000	474,600
Omaha	298,682	+32%	+3.5%	2,206,000	441,200
Nebraska Total	298,682			2,206,000	441,200

TABLE C-2
Des Moines, Council Bluffs and Davenport, Iowa Summary of Vehicle Population and Inspection Facility Requirements

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)		(9)	(10)
Inspection Area	1977 Registered Light Duty Vehicles	Average Eight Year Historical Growth (%)	Projected 1985 Light Duty Vehicles	Projec[illegible] 198[illegible] Inspections	Required Inspection Lanes		Required Inspection Facilities			Minimum Number of Certified Garages	Actual Number of Certified Garages
					Idle	Loaded	Idle	Loaded			
								2L	4L		
Polk County Des Moines	223,613	+27	284,000	369,000	5	9	3	1	2	140	160
Pottawattamie County Council Bluffs	63,112	+19	75,000	98,000	2	3	1	0	1	40	34
Scott County Davenport	111,956	+29	144,000	188,000	3	5	2	1	1	70	70
Column Total	398,681		504,000	655,000	10	17	6	2	4	250	264

Column References:

1. Source: Iowa DOT
2. Source: Iowa DOT
3. Col. 2 applied to Col. 1
4. Based on assumed retesting rate of 30%

5&6. Throughput estimates of 80,000 vehicles per lane for idle mode test and 42,000 vehicles per lane for loaded mode test (See Appendix B)

7. Two inspection lanes per idle mode facility
8. Four inspection lanes per loaded mode facility, allowing two lanes for residual vehicle inspections if necessary
9. Based on Booz, Allen & Hamilton estimate of maximum of 2,000 vehicles per certified garage
10. Source: Iowa Office of Safety Programs

of test lanes. (See Appendix B for the details of the throughput procedure.) Since each idle mode test facility will have two lanes, the required number of two-lane idle mode inspection facilities in Des Moines is three. Since loaded mode test facilities are four lanes each with a two-lane facility for the remaining lanes, there will be two four-lane facilities and one-two-lane facility.

Assuming that an average private garage would perform a maximum of 2,000 inspections per year, the minimum number of garages required to support a decentralized inspection program was calculated to be 140. Currently, the Des Moines area has approximately 160 garages certified for the change of ownership safety inspection program. It is expected that these garages would participate in the emissions inspection program and could accommodate the annual emissions inspections.

The results for Council Bluffs were computed similarly. For centralized programs, Council Bluffs will require two idle lanes and three loaded lanes. This converts to one idle facility and one four-lane loaded facility. The current number of certified garages (34) will be insufficient for the private garage emissions inspection program. At least four additional certified garages will be required.

For Davenport, the centralized programs will require three idle test lanes and five loaded test lanes. This converts to two idle test facilities and one four-lane and one two-lane loaded test facility. The current number of certified garages (70) will be sufficient for the private garage emissions inspection program.

(2) Kansas

The data in Table C-3 were used to calculate the number of inspection lanes and facilities that will be required in each program area. Data for these calculations were obtained from the Kansas Division of Motor Vehicles.

For the centralized programs, the results indicate that Johnson and Wyandotte Counties (Kansas City) will require six centralized idle mode test lanes and 12 lanes for the centralized loaded mode test. These results were

TABLE C-3
Kansas City and Wichita, Kansas
Summary of Vehicle Population and Inspection Facility Requirements

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)		(9)	(10)
Inspection Area	1977 Registered Light Duty Vehicles	Average Eight Year Historical Growth (%)	Projected 1985 Light Duty Vehicles	Projected 1985 Inspections	Required Inspection Lanes		Required Inspection Facilities			Minimum Number of Certified Garages	Actual Number of Certified Garages
					Idle	Loaded	Idle	Loaded			
								2L	4L		
Johnson County Wyandotte County Kansas City	279,951	+31	330,000	429,000	6	11	3	0	3	165	181
Sedgwick County Wichita	234,429	+15	270,000	349,000	5	9	3	1	2	135	143
Column Total	514,380		600,000	778,000	11	21	6	1	5	300	324

Column References:

1. Source: Kansas Division of Vehicles
2. Source: Kansas Division of Vehicles
3. Col. 2 applied to Col. 1
4. Based on assumed retest rate of 30%

5&6. Throughput estimates of 80,000 vehicles per lane for idle mode test and 42,000 vehicles per lane for loaded mode test (See Appendix B)

7. Two inspection lanes per idle mode facility
8. Four inspection lanes per loaded mode facility, allowing two lanes for residual vehicle inspections if necessary
9. Based on Booz, Allen & Hamilton estimate of maximum of 2,000 vehicles per certified garage
10. Source: Kansas Motor Vehicle Inspection Administration

obtained by dividing the projected number of inspections in 1985 (the constraining year for the five-year life cycle) by 80,000 inspections per year per lane for idle and 42,000 inspections per year per lane for loaded. These figures are the estimated throughputs for the two types of test lanes. (See Appendix B for the details of the throughput estimation procedure.) Since each idle mode test facility will have two lanes, the required number of idle mode inspection facilities in Kansas City is three. Since loaded mode test facilities are assumed to be four lanes each, with a two-lane facility for the remaining lanes, the requirement will be three four-lane facilities.

Assuming that an average private garage would perform a maximum of 2,000 inspections per year, the minimum number of garages required to support a decentralized inspection program was calculated to be 180. Currently Kansas City has approximately 181 garages certified for the change of ownership safety inspection program.

The results for Wichita were computed similarly. For centralized programs, Wichita will require five idle lanes and nine loaded lanes. This converts to three two-lane idle facilities and two four-lane and one two-lane loaded facilities. The current number of certified garages (143) is sufficient for a private garage inspection program.

(3) Nebraska

The data in Table C-4 were used to calculate the number of inspection lanes and facilities that will be required in each program area. Data for these calculations were obtained from the Nebraska Department of Motor Vehicles.

For the centralized programs, the results indicate that Douglas and Sarpy Counties (Omaha) will require seven idle mode test lanes and 13 lanes for the loaded mode test. These results were obtained by dividing the projected number of inspections in 1985 (the constraining year for the five-year life cycle) by 80,000 inspections per year per lane for idle and 42,000 inspections per year per lane for loaded. These figures are the estimated throughputs for the two types of test lanes. (See Appendix B for the details of the throughput estimation procedure.) Since each idle mode test

TABLE C-4
Omaha, Nebraska
Summary of Vehicle Population and
Inspection Facility Requirements

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)		(9)	(10)
Inspection Area	1977 Registered Light Duty Vehicles	Average Eight Year Historical Growth (%)	Projected 1985 Light Duty Vehicles	Projected 1985 Inspections	Required Inspection Lanes		Required Inspection Facilities			Minimum Number of Certified Garages	Actual Number of Certified Garages
					Idle	Loaded	Idle	Loaded			
								2L	4L		
Douglas County Sarpy County Omaha	298,682	+32	395,000	513,000	7	13	4	1	3	190	440

Column References:

1. Source: Nebraska DMV
2. Source: Nebraska DMV
3. Col. 2 applied to Col. 1
4. Based on assumed retest rate of 30%

5&6. Throughput estimates of 80,000 vehicles per lane for idle mode test and 42,000 vehicles per lane for loaded mode test (See Appendix B)

7. Two inspection lanes per idle mode facility
8. Four inspection lanes per loaded mode facility, allowing two lanes for residual vehicle inspections if necessary
9. Based on Booz, Allen & Hamilton estimate of maximum of 2,000 vehicles per certified garage
10. Source: Nebraska Periodic Motor Vehicle Inspection Program

facility will have two lanes, the required number of idle mode inspection facilities in Omaha is four (seven lanes rounded to four two-lane facilities). Since loaded mode test facilities are assumed to have four lanes each, with a two-lane facility for the remaining lanes, the requirement will be three four-lane facilities and one two-lane facility.

Assuming that an average private garage would perform a maximum of 2,000 inspections per year, the minimum number of garages required to support a decentralized inspection program was calculated to be 190. The Omaha area currently has 440 certified garages.

APPENDIX D
DETAILED COST DATA AND EQUATIONS

APPENDIX D

DETAILED COST DATA AND EQUATIONS

This appendix includes the following eight sections describing the assumptions and data used in the cost analysis of the program options.

- Cost Element Requirements
- Cost Element Assumptions
- Other Assumptions and Findings for Cost Analysis
- Building and Land Investments
- Labor Start-up Costs
- Labor Operating Costs
- Inspection Fee Calculation Method
- Cost Effectiveness Calculation Method

1. COST ELEMENT REQUIREMENTS

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TABLE D-1
Cost Element Requirements: State- and Contractor-Operated Programs

	Idle Test	Loaded Test
Building[a]*		
- lanes	149m^2 per lane (1,600 ft.^{2})	186m^2 per lane (2,000 ft.^{2})
- office	149m^2 per facility (1,600 ft.^{2})	149m^2 per facility (1,600 ft.^{2})
- paving	3013m^2 per two lane facility (32,400 ft.^{2}))	3013m^2 per two lane facility and 6026m^2 per four lane facility
Land[b]	4456m^2 per two lane facility (1.1 acres)	5261m^2 per two lane facility (1.3 acres) and 8903m^2 per four lane facility (2.2 acres)
Equipment[b]		
- analyzer	1 per lane	1 per lane
- dynamometer	Not applicable	1 per lane
- computer	1 per facility and 1 per Headquarters	1 per facility 1 per Headquarters
Start-Up Labor	See Tables D-10 and D-11	See Tables D-10 and D-11
Program Design	Contracted	Contracted
Start-Up Training	Dependent upon number of inspectors	Dependent upon number of inspectors
Start-Up Public Information	Dependent upon number of vehicles in first year of program	Dependent upon number of vehicles in first year of program
Operating Labor	See Tables D-13 and D-14	See Tables D-13 and D-14
Maintenance	Service contract based on equipment value	Service contract based on equipment value
Public Information	Dependent upon number of vehicles in life cycle of program	Dependent upon number of vehicles in life cycle of program
Other Operating Costs	Dependent upon number of lanes, includes costs of utilities, supplies, and outside services (based on GCA data)	Dependent upon number of lanes, includes costs of utilities, supplies, and outside services (based on GCA data)

*Notes for Table D-1 appear on the following page.

Notes For Table D-1

a. Booz, Allen and Hamilton estimates based on building specifications for existing programs

b. Estimates based on land requirements for Phoenix and Tuscon, Arizona programs (Hamilton Test System, Inc.)

TABLE D-2

Cost Element Requirements: Private Garage-Operated Programs

	Idle Test
Building - lanes - office - paving Land	A challenge facility located within an existing State building would be used; leasing cost expected to be insignificant and was not estimated. One challenge garage per area was assumed.
Equipment - analyzer - dynamometer - computer	1 per garage and challenge facility Not required Not required
Start-up Labor	See Table D-12
Program Design	Contracted
Start-Up Training	Included in labor costs (other training costs were minimal in comparison to other costs)
Start-Up Public Information	Dependent upon number of vehicles in first year of program
Operating Labor	See Table D-15
Maintenance	Maintenance costs built into garage overhead rates
Public Information	Dependent upon number of vehicles in life cycle of program
Other Operating Costs	Inspection facility operating costs built into garage overhead rates

2. COST ELEMENT ASSUMPTIONS

TABLE D-3
Cost Element Assumptions: State-and Contractor-Operated Programs (All Costs in 1978 Dollars)

	Idle Test	Loaded Test
Building[a]*		
- Lanes - Office	\$279.57 per m^2 (\$26 per ft.^{2})	\$279.57 per m^2 (\$26 per ft.^{2})
- Paving	\$10.75 per m^2 (\$1 per ft.^{2})	\$10.75 per m^2 (\$1 per ft.^{2})
Land[a]	Kansas - \$33.90 per m^2 (\$3.15 per ft.^{2}) Iowa - \$10.00 per m^2 (\$0.93 per ft.^{2}) Nebraska - \$8.70 per m^2 (\$0.81 per ft.^{2})	Kansas - \$33.90 per m^2 (\$3.15 per ft.^{2}) Iowa - \$10.00 per m^2 (\$0.93 per ft.^{2}) Nebraska - \$8.70 per m^2 (\$0.81 per ft.^{2})
Equipment[b]		
- Analyzer	\$27,000 per lane	\$27,000 per lane
- Dynamometer	Not required	\$7,500 per lane
- Computer	\$40,000 per facility and \$250,000 per Headquarters	\$ 40,000 per facility and \$250,000 per Headquarters
Start-Up Labor	See Tables D-10 and D-11	See Tables D-10 and D-11
Program Design[c]	\$150,000 per program	\$150,000 per program
Start-Up Training[d]	\$346 per inspector	\$346 per inspector
Start-Up Public Information[e]	\$0.29 per vehicle	\$0.29 per vehicle
Operating Labor	See Tables D-13 and D-14	See Tables D-13 and D-14
Maintenance[f]	Six percent of original equipment value	Six percent of original equipment value
Public Information[e]	\$0.10 per vehicle	\$0.10 per vehicle
Other Operating Costs[g]	\$4,000 per lane	\$4,000 per lane

*Notes for Table D-3 can be found on the following page.

Notes For Table D-3

a. Estimates based on local average building and land costs.

b. Estimate based on data supplied by Hamilton Test Systems, Inc. Less automated systems could be used, however, labor costs for data handling would increase.

c. Booz, Allen and Hamilton estimate.

d. Based on data supplied by Portland Vehicle Inspection Program and published data in "Viable Alternative Types of Inspection/Maintenance Programs for St. Louis", June, 1977, GCA Corporation, Bedford Massachusetts prepared for U.S. E.P.A.

e. Based on data published by GCA Corporation (*op. cit*.) and confirmed by Hamilton Test Systems, Inc.

f. Based on data supplied by Portland Vehicle Inspection Program.

g. Based on data supplied by GCA Corporation (*op. cit*.)

TABLE D-4
Cost Element Assumptions: Private Garage-Operated Programs
(All Costs in 1978 Dollars)

	Idle Test
Building - lanes	Not required
- office	Not required
- paving	Not required
Land	Not required
Equipment - analyzer	$2,200 per facility
- dynamometer	Not required
- computer	Not required
Start-Up Labor	See Table D-12
Program Design	$150,000
Start-Up Training	Included in labor costs
Start-Up Public Information	$0.29 per vehicle
Operating Labor	See Table D-15
Maintenance	Included in overhead rate
Public Information	$0.10 per vehicle
Other Operating Costs	Included in overhead rate

3. OTHER ASSUMPTIONS AND FINDINGS FOR COST ANALYSIS

3. OTHER ASSUMPTIONS AND FINDINGS FOR COST ANALYSIS

- Program life cycle for cost estimating purposes will be five years
- All cost elements will be subject to an average inflation rate of 5 percent per year from 1978 to 1985. Costs can be converted by multiplying 1978 costs by the following factors each year:

Year	Cost Index
1978	1.00
1979	1.05
1980	1.10
1981	1.16
1982	1.21
1983	1.28
1984	1.34
1985	1.41

- Inspection equipment in the State and contractor test modes will be computerized to facilitate the data collection procedure. Some savings could be achieved with less automated equipment, however, the data quality would be compromised.
- The cost of the building, land and equipment will be amortized over the life cycle of the program; the cost of the land (plus appreciation) will be recovered at the completion of the program.
- Land values will appreciate 7.7 percent after five years.*
- All programs will collect test result data to monitor the reduction in emissions levels.
- Public information programs will be intensive to ensure a strong start for the program. These costs have been estimated at a high rate.

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* Source: Comparative Cost Analysis for Decisions to Lease or Purchase General Purpose Real Property, Circular A-104, Office of Management and Budget, Washington.

- Training in emissions repair work for private garage mechanics will be available through local community colleges paid for by the State I/M program. For the private garage-operated program this training will be combined with an inspection testing training program as part of the State I/M program.

- Contractor costs will include a profit calculated at 10 percent of their total costs.

- The number of certified private garages in each study area will not increase beyond the 1978 level. In those cases where the current number of garages is less then the required minimum calculated in Tables C-2, C-3, and C-4, it is expected that additional garages will be certified.

- Programs requiring funds for capital investments and starting costs will borrow money over a five year term at an interest rate of 10 percent for State agencies and contractors and a rate of 12 percent for private garages.

- Salaries were found to be comparable for each of the study areas according to wage statistics published by the Bureau of Labor Statistics and a comparison of State personnel pay scales and categories.

- Building costs have been estimated by conventional engineering estimating procedures. Data from existing programs indicate that there may be a significant difference in building costs depending upon factors such as location and structure specifications. New Jersey and Hamilton Test Systems have built facilities in the $40 to $60 per square foot range while Oregon has built a facility for as little as $13 per square foot. Our independent estimate is close to the midpoint of these extremes.

- Several of the existing programs have leased facilities from private developers. There are advantages to this mode of occupancy; however, the wide latitude of possible lease conditions which affect the cost make it too complex to estimate until more detailed site and building specifications are available.

4. BUILDING AND LAND INVESTMENTS

4. BUILDING AND LAND INVESTMENTS

(1) Summary of Building Cost Data

Building costs for centralized inspection techniques and data. Due to the unique nature of a vehicle inspection facility, several special features were incorporated into the building and site. The additional features included substantial exhaust fan systems and large paved area. The cost estimates were found to be in line with local building costs in each of the five study areas.

The following computations were made in the estimation of building requirements and costs.

1. Building Specification:

- Steel Frame
- Concrete Floor
- Finished Office
- Overhead Doors
- Painted Walls
- Small Restrooms
- Forced Air HVAC
- Underfloor and Roof Exhaust Systems.

2. Size of Basic Structure:

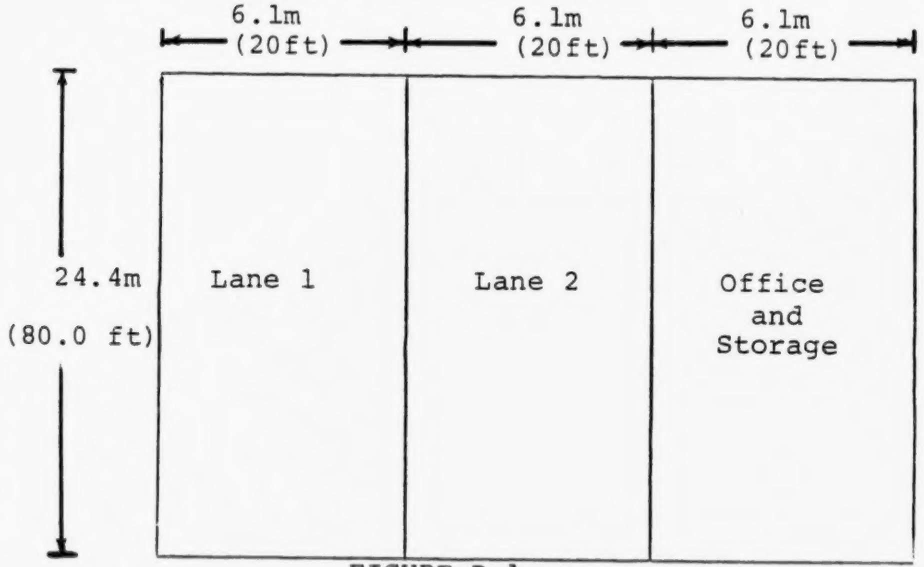

FIGURE D-1
Two Lane Centralized Idle Test Inspection Facility
Total Area = 446.5 square meters (4800 square feet)

3. Cost Calculation (1978 Dollars):

- Basic Cost:

  At $230.74 per square meter ($21.45 per square foot) equals $103,025.

- Allowance for No Central Heat in Inspection Areas:

  At $16.30 per square meter ($1,52 per square foot) equals $4,857.

- Increase for Space Heating in Inspection Areas:

  At $7.64 per square meter ($0.71 per square foot) equals $2,277.

- Increase for Office Construction:

  At $29.52 per square meter ($2.75 per square foot) equals $4,384.

- Increase for Special Exhaust Fans in Inspection Areas:

  At $67.11 per square meter ($6.25 per square foot) equals $20,000.

TOTAL COST FOR FACILITY:

- Sum of costs equals $124,828
- Average cost per square meter equals $279.57 ($26 per square foot).

(2) Summary of Land Cost Data

1. Introduction

In order to estimate what the approximate costs would be to build auto emission testing facilities in the six cities studied, current land costs were collected for each metropolitan area according to general locational criteria. The sources of information for each city are shown in Table D-5. These sources were asked to represent market conditions as of August 1978.

An effort was made to obtain cost data based on actual sites and buildings for sale or lease in downtown, in-city and suburban locations. General criteria included:

- One-half to one acre of land
- Industrial or commercial zoning
- Access to major arterial
- Normal utility service at site.

Each city is summarized as to findings in Tables D-6, D-7, and D-8, and described according to current market conditions in the following paragraphs. When reviewing the cost data several factors should be understood:

- While it is likely that the test facility could be built in either commercial or industrial zoned areas, commercial zoned sites are invariably higher in cost by $11-54 per square meter ($1-5 per square foot).

- Several cities have industrial or commercial sites that have been made available through urban renewal, community development of EDA* projects. In most of the cities surveyed the land prices were competitive with private sector offerings. However, a notable exception is Wichita where urban renewal sites are offered at fully $4 per square meter ($1.00 per square foot) under current market prices.

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* Economic Development Administration, U. S. Department of Commerce.

TABLE D-5
Sources of Cost Information by City

Kansas City, Kansas	B.A. Karbank & Co. 816-221-4488
Wichita, Kansas	J.P. Weigand Co. 316-262-6407
	Wichita Urban Renewal Agency 316-268-4381
Omaha, Nebraska	Roger Haney Land Corp. 402-331-6655
Des Moines, Iowa	Chamberlain, Kirk & Cline, Inc. 515-288-9501
Council Bluffs, Iowa	Council Bluffs Industrial Foundation 712-325-1000
Davenport, Iowa	Mel Foster Co. Inc. 319-324-1081

TABLE D-6
Summary of Locational Cost Data for Kansas

Location City/County	Land Cost Per Square Meter	General Comments
(1) Kansas City, Kansas		
In-City	$54.00-108.00	Johnson Co. high growth area for upper income residential/office/commercial retail development
Johnson Co.	$13.50-27.00	
Wyandotte Co.	$11.00-19.00	Public and privately owned sites available in-city
(2) Wichita		
In-City	$16.00-27.00	Several urban renewal sites available $3.75-6.00
Sedgwick Co.	$16.00-43.00	
		Existing space lease costs run $12.25-38.75 per annum
		Growth areas to east and west of city

TABLE D-7
Summary of Locational Cost Data
for Omaha, Nebraska

Location City/County	Land Cost Per Square Meter	General Comments
(1) Omaha		
In-City	$6.00-7.00	Growth areas to the southwest along I-80
Douglas Co.	$6.50-12.50	Industrial parks have broad representation of activities
Sarpy Co.	$6.50-12.50	

TABLE D-8
Summary of Locational Cost Data
for Iowa

Location City/County	Land Cost Per Square Meter	General Comments
(1) Council Bluffs		Industrial growth south and southwest primarily in I-80/29 corridor
In-City	$5.50-11.00	
Pottawattamie Co.	$1.50-11.00	Residential growth moving east and southeast
		Wide choice of freestanding and industrial park sites
(2) Des Moines		Healthy industrial market
Downtown	$129.00-161.00	Existing space lease costs running $21.00-37.50 per sq. meter per annum
In-City	$13.50-17.00	
Polk County	$11.00-16.00	Trucking/warehousing activity concentrated north of city
		Urbandale choice area for residential and industrial/commercial
(3) Davenport-Bettendorf		Few freestanding sites available
In-City	$4.75-7.50	Several existing warehouses for sale in $161 range
Scott County	$4.75-6.50	
		Residential development moving north
		I-61 and 74 corridors most convenient to population distribution

- Existing warehouse space varies tremendously from city to city in terms of cost, availability, location, and suitability. Thus lease terms and costs were not explored in any detail.
- Land costs do not include fees, financing, or other charges.

2. Cost for Kansas City, Kansas

Industrial and commercial zoned land in prime in-city areas in Kansas City, Kansas, generally costs $54 to $108 per square meter ($5 to $10 per square foot).

Industrial zoned land oriented to the I-35 and I-435 corridors in Johnson County is available at prices ranging from $13.50 to $27.00 per square meter. Industrial zoned land in the I-635 corridor in Wyandotte County ranges from $11.00 to $18.50 per square meter. Johnson County has significant growth in quality residential development, regional shopping centers, and industrial parks and therefore, commands generally higher prices for well-located developable sites.

3. Cost for Wichita, Kansas

Wichita has an ample supply of commercial and industrial zoned properties within the city and in the suburban areas suitable for testing stations. Vacant developable sites as well as existing warehouse structures appropriate for conversion are currently available in convenient locations. Lease rates for existing buildings containing approximately 900 square meters (9700 square feet), open bays, and overhead doors, range from $12.25 to $38.75 per square meter ($1.10 to $3.60 per square foot) depending upon location.

Vacant developable land is available for sale within two municipal industrial parks in the cost range of $5.50 to $6.50 per square meter ($0.50 to $0.60 per square foot).

The growth areas in Wichita are to the east where quality residential and commercial development has occurred, and to the west where industrial development has spread. Therefore, land costs in the eastern corridor along Kellog and Oliver currently range from $18.25 to $43.00 per square meter ($1.70 to $4.00 per square foot). In contrast, land costs in the central morthern area of Wichita for industrial zoned sites range from $3.75 to $6.50 per square meter. Land costs for industrial zoned land in the outlying areas to the west and south range from $16.00 to $21.50 per square meter.

4. Cost for Omaha, Nebraska

Omaha is situated across the Missouri River from Council Bluffs, Iowa and has a more developed industrial market sector. The major growth areas have been in the I-80/29 corridors in the southwest quadrant of the Omaha area. Industrial park sites in this area are available at costs ranging from $6.50 to $12.50 per square meter in both Douglas and Sarpy Counties. Sites are available in town in EDA* funded projects for $6.00 to $7.00 per square meter.

5. Cost for Des Moines, Iowa

Industrial development is in a healthy growth trend with sites and building space moving rapidly in the market. Industrial parks and freestanding sites are available along Fleur in the vicinity of the airport for $11.00 to $12.50 per square meter. Industrial park sites in the Urbandale area convenient to major arterials would average $14.00 per square meter. Smaller sites of an acre of less in the north central part of Des Moines range from $11.00 to $16.50 per square meter. Sites in the downtown and area south of the Loop are quire expansive at approximately $129 per square meter.

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* Economic Development Administration, U. S. Department of Commerce.

Des Moines also has a good stock of existing warehouse structures in various sections of the city which are available for lease. Examples include an 800 square meter building on Highway 69 North which can be leased at $21.00 per square meter, and a 900 square meter building in Urbandale which can be leased at $27.00 per square meter. Existing structures downtown are currently renting between $32.00 and $37.00 per square meter.

6. Cost for Council Bluffs, Iowa

The industrial market in Council Bluffs has been fairly soft over the past several years and there are numerous industrial park and freestanding sites available as well as some existing buildings in the city and in suburban locations. The primary growth movements have been to the east and southeast along the I-29/80 corridor. Industrial development is concentrated in the south and southwestern quadrant along I-29/80. The Council Bluffs Industrial Foundation reported that there is no significant cost differential in industrial zoned sites in suburban or city locations. Sites are available for around $5.50 per square meter in the CB Industrial Park and the Iowa and Nebraska Industrial Park which together have 190 of 350 hectacres salable. The Cattleman property adjacent to the Iowa and Nebraska Industrial Park in the I-29/80 corridor is currently on the market at a reputed sales price of $7.50 per square meter. While this is an estate sale, the low asking price indicates the continuing soft market.

7. Cost for Davenport, Iowa

Davenport is part of the Quad Cities metropolitan area which is comprised of Davenport and Bettendorf situated north across the Mississippi River from Rock Island and Moline, Illinois. There are numerous industrial park sites available in the Davenport-Bettendorf area oriented to the I-74, I-80, and Brady Road (Highway 61) corridors. Prices range from $5.00 to $7.50 per square meter.

Existing buildings are available for lease or acquisition particularly in the I-67 and I-74 interchange area along the river. There are few freestanding sites available that are an acre or less in size and zoned industrial. New residential and commercial development has been moving in a north-central direction from the city.

8. Calculation of Weighted Average Land Costs Per State

To calculate the weighted average land cost by state, we assumed that each program area would have one facility located in-town and one facility in a suburban area. Table D-9 describes the calculations and the results obtained for weighted average land costs per state.

TABLE D-9

Calculation of Weighted Average Land Costs By State

Program Area	Proposed Idle Inspection Lanes In-Town	Average Land Costs In-Town (per square meter)	Proposed Idle Inspection Lanes Suburban	Average Land Costs Suburban (per square meter)	Weighted Average Land Cost (per square meter)
Kansas City	2	$80.60	4	$18.80	
Wichita	2	$21.50	2	$29.60	
Kansas TOTAL					$33.90
Des Moines	2	$16.60	4	$ 6.70	
Davenport	2	$ 6.70	2	$14.50	
Council Bluffs	2	$ 8.70	0	$ 6.20	
Iowa TOTAL					$10.00
Omaha	2	$ 7.10	2	$10.20	
Nebraska TOTAL					$ 8.70

5. LABOR START-UP COSTS

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TABLE D-10

Estimated Start-Up Labor Costs
State Operated Program - Idle and Loaded Mode Tests

Position	Annual Salary	Kansas, Iowa & Nebraska	
		Number	Cost
Administrator	$21,000	1	$21,000
Project Officers	17,500	2	35,000
Contracting and Building Officer	17,500	1	17,500
Inspector Training Officer*	-	1	
Public Information Officer*	-	1	
Mechanic Training Officer	14,700	1	14,700
Technicians	11,600	1	11,600
Clerical and Secretarial	8,700	3	26,100
Subtotal			125,900
Overhead and Fringe (30%)			37,800
TOTAL		11	$163,700

*Costs included as part of Public Information and Training Cost elements.

TABLE D-11

Estimated Start-Up Labor Costs
Contractor Operated Program Loaded and Idle Mode Test

Position	Annual Salary	Kansas, Iowa and Nebraska	
		Number	Costs
Contractor			
State Program Manager	$24,000	1	$24,000
Data Systems Manager	19,400	1	19,400
Contracting/Budget Officer	18,000	1	18,000
Secretary	11,700	1	11,700
Public Information Officer*	-	-	-
Training Officer*	-	-	-
Clerical	9,000	1	9,000
Equipment Technician	12,200	1	12,200
Subtotal			94,300
Overhead and Fringe (30%)			28,300
TOTAL		6	$122,600
State Agency			
Administrator	21,800	1	21,800
Assistant Administrator	18,900	1	18,900
Contract Monitor	16,000	1	16,000
Mechanic Training	14,700	1	14,700
Secretary	9,000	1	9,000
Subtotal			80,400
Overhead and Fringe (30%)			24,100
TOTAL		5	$104,500

*Costs included as part of Public Information and Training Cost elements.

TABLE D-12
Estimated Start Up Labor Costs
Private Garage Operated Program - Idle Mode Test

Position	Salary	Kansas, Iowa		Nebraska	
		Number	Cost	Number	Cost
State Agency					
Administrator	$21,000	1	$21,000	0	
Garage Inspector Supervisor	17,000	1	17,000	0	
Statistician/ Data Analyst	17,500	1	17,500	1	$17,500
Public Information Officer*					
Maintenance Technician	12,000	1	12,000	1	12,000
Garage Inspector Training	14,700	1	14,700	1	14,700
Secretary and Clerical	8,700	2	17,400	1	8,700
Subtotal			99,600		52,900
Overhead and Fringe (30%)			29,900		15,900
TOTAL		7	$129,500	4	$68,800

*Costed separately as part of Public Information and Training costs elements.

6. LABOR OPERATING COSTS

TABLE D -13
Estimated Operating Labor Costs
State Operated Program - Idle Mode Test
(Loaded Mode Test Data in Parentheses
(if Different from Idle Test)

Position	Annual Salary	Kansas		Iowa		Nebraska	
		Number	Cost	Number	Cost	Number	Cost
Administrator	$21,000	1	$21,000	1	$21,000	1	$21,000
Assistant Administrator	19,400	1	19,400	1	19,400	1	19,400
Budget Officer	17,500	1	17,500	1	17,500	1	17,500
Data System Manager	17,500	1	17,500	1	17,500	1	17,500
Public Information Officer*							
Mechanic Training Officer	14,700	1	14,700	1	14,700	1	14,700
Quality Assurance Technician	11,500	1	11,500	1	11,500	1	11,500
Maintenance Mechanic	10,200	2	20,400	2	20,400	2	20,400
Computer Programmer	14,500	1	14,500	1	14,500	1	14,500
Clerical and Secretarial	8,700	2	17,400	2	17,400	2	17,400
Station Managers	11,800	6	70,800	6	70,800	4	47,200
Inspectors	9,100	35 (64)	318,500 (582,400)	35 (58)	318,500 (527,800)	23 (41)	209,300 (373,100)
Subtotal			543,200 (807,100)		543,200 (752,500)		410,400 (574,200)
Overhead and Fringe (30%)			163,000 (242,100)		163,000 (226,000)		123,100 (172,300)
Overtime for Inspectors			27,300 (50,100)		27,300 (45,500)		18,200 (31,900)
TOTAL		52 (81)	733,500 (1,099,300)	52 (75)	733,500 (1,024,000)	40 (58)	551,700 (778,400)

* Costs included as part of Public Information and Training cost estimates.

TABLE D-14
Estimated Operating Labor Cost
Contractor Operated Program - Idle Mode Test
(Loaded Mode Test Data in Parentheses if Different from Idle)

Position	Annual Salary	Kansas		Iowa		Nebraska	
		Number	Cost	Number	Cost	Number	Cost
CONTRACTOR							
Program Manager	$24,000	1	$24,000	1	$24,000	1	$24,000
Data System Manager	19,400	1	19,400	1	19,400	1	19,400
Budget Officer	15,000	1	15,000	1	15,000	1	15,000
Public Information Officer*							
Secretary/Administrative Ass't	11,700	1	11,700	1	11,700	1	11,700
Equipment Technicians	12,200	2	24,400	2	24,400	2	24,400
Station Managers	13,400	6	80,400	6	80,400	4	53,600
Inspectors** Fulltime	8,900	23 (43)	204,700 (382,700)	23 (40)	204,700 (356,000)	16 (28)	142,400 (249,200)
Partime	3,700	11 (20)	40,700 (74,000)	11 (18)	40,700 (66,600)	7 (13)	25,900 (48,100)
Subtotal			420,300 (631,600)		420,300 (597,500)		316,400 (445,400)
Overhead and Fringe (30%)			126,100 (189,500)		126.100 (179,300)		95,000 (133,600)
TOTAL		46 (75)	546,400 (821,100)	46 (70)	546,400 (776,800)	33 (51)	411,400 (579,000)
STATE AGENCY							
Administrator	21,000	1	21,000	1	21,000	1	21,000
Assistant Administrator	18,900	1	18,900	1	18,900	1	18,900
Statistician/Data Analyst	14,300	1	14,300	1	14,300	1	14,300
Secretary	8,700	1	8,700	1	8,700	1	8,700
Contract Monitor	16,000	1	16,000	1	16,000	1	16,000
Quality Assurance	14,300	2	28,600	2	28,600	2	28,600
Mechanic Training	14,700	1	14,700	1	14,700	1	14,700
Subtotal			122,200		122,200		122,200
Overhead and Fringe (30%)			36,700		36,700		36,700
TOTAL		8	158,900	8	158,900	8	158,900

* Cost included as part of Public Information cost elements.

TABLE D-15
Estimated Operating Labor Costs
Private Garage Operated Program - Idle Mode Test

Position	Salary (1978 Dollars)	Kansas		Iowa		Nebraska*	
		Number	Cost	Number	Cost	Number	Cost
State Agency							
Administrator	$21,000	1	$21,000	1	$21,000	0	
Garage Inspector Supervisor	17,000	1	17,000	1	17,000	0	
Statistician/Data Analyst	17,500	1	17,500	1	17,500	1	$17,500
Public Information Officer**							
Maintenance Technician	12,000	1	12,000	1	12,000	1	12,000
Garage Inspector Training Officer	14,700	1	14,700	1	14,700	1	14,700
Garage Inspectors***	11,000	8	88,000	6	66,000	3	33,000
Secretaries/Data Clerks	8,700	3	26,100	3	26,100	2	17,400
Subtotal			196,300		174,300		94,600
Overhead and Fringe (30%)			58,900		52,300		28,400
TOTAL		16	255,200	14	226,600	8	123,000
	Inspection Labor Cost Including Overhead	Average Annual Inspections	Cost (dollars)	Average Annual Inspections	Cost (dollars)	Average Annual Inspections	Cost (dollars)
GARAGES							
Inspector	$3.20**** ($1.60 in Nebraska)	780,000	2,500,000	650,000	2,100,000	600,000	1,000,000

* Nebraska program will be incorporated into the existing annual safety inspection program.

** Cost included as part of Public Information cost estimates.

*** Based on average of 100 garages per inspector obtained from "Analysis of the Practical Application of an Inspection and Maintenance Program in the Public and Private Sectors" prepared for Colorado, page III-5, and conversation with William Greiss, New Jersey Enforcement Division.

**** Based on an assumed garage service rate of $16.00 per hour and a 12-minute inspection time in Kansas and Iowa. In Nebraska, the inspection time is reduced to a six-minute component of the existing garage safety inspection since many of the administrative functions of the inspection (noting vehicle identification and processing forms) are performed as part of the safety inspection.

7. INSPECTION FEE CALCULATION

7. INSPECTION FEE CALCULATION

This section presents the equations used for calculating the life cycle costs (annualized) and the inspection fee. By using these equations it is possible to duplicate the results presented in the cost analysis section and to compute the sensitivity of the analysis to changes in the variables.

(1) Variables Used in the Inspection Fee Calculation

In calculating the inspection fee, estimates for the cost variables were made as shown below in Table D-16. The necessary references for calculating these estimates are also indicated.

Table D-16
Variables Used in the Inspection Fee Calculation

Variable Name	Description	Reference
BLD	Building Cost	Tables D-1 to D-4 and Section D-4
LND	Land Cost	Tables D-1 to D-4 and Section D-4
EQP	Equipment Cost	Tables D-1 to D-4
SLB	Start-Up Labor Cost	Tables D-10 to D-12
PDN	Program Design	Tables D-1 to D-4
SPI	Start-Up Public Information Cost	Tables D-1 to D-4
STR	Start-Up Training Cost	Tables D-1 to D-4
OLB	Annual Operating Labor Cost	Tables D-13 to D-15
EQM	Annual Equipment Maintenance Cost	Tables D-1 to D-4
OPI	Annual Operating Public Information Cost	Tables D-1 to D-4
OOC	Other Annual Operating Costs	Tables D-1 to D-4
ACP	Annual Contractor Profit	Section D-3
I81	Inflation Index 1978 to 1977	Section D-3
LAI	Land Appreciation Index 1981 to 1985	Section D-3
AFV	Average Annual Fee Producing Vehicles	Table C-1

(2) Calculation for Conversion to "Current" Dollars

Since all costs were estimated in 1978 dollars, it was necessary to inflate them to dollars during the life cycle 1981 to 1985 (referred to as current dollars).

Capital investments and start-up costs were inflated to 1981 dollars by multiplying the sum of the capital investments and start-up costs by I81. This result, shown below, yields the total capital investments and start-up costs, referred to as TKS.

$$\text{TKS} = [\text{BLD} + \text{LND} + \text{EQP} + \text{SLB} + \text{PDN} + \text{SPI} + \text{STR}] \times \text{I81}$$

Annual operating costs were inflated to current dollars by multiplying the sum of the annual operating costs in 1978 dollars by an average inflation factor for the life cycle 1981 to 1985. This yields the average annual operating cost for the life cycle, referred to as AOC.

$$\text{AOC} = [\text{OLB} + \text{EQM} + \text{OPI} + \text{OOC}] \times \frac{\text{I81} \times \sum_{i=1}^{5} (1.05)^{i}}{5}$$

(3) Calculation of Annualized Capital and Start-Up Costs

The capital investments and start-up costs are all incurred at the beginning of the life cycle. In financing these costs, the payments for interest and principal are spread throughout the life cycle. In addition the salvage value of the land at the end of the life cycle must be credited, however, this salvage value must also be discounted back over the life cycle.

The annualized capital and start-up costs can be calculated by multiplying the total capital investments and start-up costs by a factor which amortizes these costs over the life cycle. The result is the annualized capital and start-up cost, referred to as AKS.

$$\text{AKS} = \text{TKS} - \frac{(1 + 0.1)^{5} \times 0.1}{(1 + 0.1)^{5} - 1}$$

To account for the salvage value the appreciated land value is credited to AKS. This value is calculated by multiplying the salvage value by an average discount rate (0.756) over the life cycle and dividing by 5 years. This revised value for AKS is calculated as follows:

$$AKS' = AKS - \frac{LND \times LAI \times I81 \times 0.756}{5}$$

This result is the annualized capital and start-up cost based on a life cycle 1981 to 1985.

(4) Calculation of Total Costs and Inspection Fee

By adding AKS' and AOC (and adding 10% to this for profit in the contractor options), we derive total average annual costs for the program. This total is one-fifth of the total life cylce cost of the program.

The equation for computing the annual fee per vehicle is shown below. It is simply the above total, divided by AFV, the average annual fee producing vehicles.

$$\text{Annual Fee per Vehicle} = \frac{AKS' + AOC}{AFV} \left(+ \frac{ACP}{AFV} \text{ if necessary}\right)$$

8. COST EFFECTIVENESS CALCULATION METHODS

8. COST EFFECTIVENESS CALCULATION METHOD

The projected 1987 I/M program and vehicle repair costs given in Tables 10, 19, and 24 were estimated as follows:

Step 1—The average annual inspection fee given in Tables 5, 14, and 23 was projected to 1987 by using an inflation rate of 5 percent per year.

Step 2—The emissions repair cost per vehicle repaired was found to be $20 in 1978 based on repair costs surveys in Arizona, Oregon, Tennessee, Alabama and New Jersey. This cost was projected to 1987 using an average inflation rate of 5 percent per year. The average repair cost per vehicle inspected was estimated by multiplying the above cost by the strigency factor (30 percent).

Step 3—The number of vehicles inspected in 1987 (initial inspection only) was determined by using the growth factors given in Appendix C.

Step 4—The total I/M program and repair cost was estimated by adding the average cost per vehicle from Step 1 to that from Step 2 and multiplying by the number of vehicles from Step 3.

APPENDIX E

GLOSSARY

GLOSSARY

AMBIENT AIR: The surrounding or outside air.

CALIBRATION GASES: A blend of HC and CO gases using nitrogen as a carrier gas.

CAPITAL INVESTMENT: Initial expenditures for goods necessary for the operation of a program (e.g., building, land and equipment).

CARBON MONOXIDE: A nonirritating, colorless, odorless gas at standard conditions which has the molecular form of CO.

CERTIFIED MECHANIC: An individual licensed by the State to inspect motor vehicle engine emissions related components and pollution control devices for compliance with specified emissions standards.

CERTIFIED STATION: A private facility licensed by the State to inspect motor vehicle engine emissions related components and pollution control devices for compliance with specified emissions standards.

DEGRADATION: The decreased effect of I/M on emission reduction due to normal wear of engine system.

DYNAMOMETER: A machine equipped with two parallel rollers which support the rear wheels of a motor vehicle. When positioned on the dynamometer the vehicle may be "driven" to simulate the loadings the engine would experience when the vehicle is operated on the road. A power absorption unit is connected to the rollers to simulate the loading from the various sources of fluid and mechanical friction present during road operation. Weights can also be coupled to the rollers to simulate the inertial effects of vehicle mass during acceleration and decelleration.

EMISSION INSPECTION PROGRAM: An inspection and maintenance program in which each vehicle is subjected at specified intervals to a test of its emissions under specified conditions. The emission levels are compared with a standard established for the vehicle class. If the emissions are higher than the standard, the vehicle is failed and must be adjusted or repaired to bring its emissions into compliance with the standards.

EXHAUST GAS ANALYZER: An instrument for sensing the amount of air contaminants in the exhaust emissions of a motor vehicle.

EXHAUST EMISSIONS: The products of combustion emitted into the ambient air from any opening downstream of the exhaust ports of a motor vehicle engine.

HEAVY-DUTY VEHICLE: Any motor vehicle designed for highway use which has a gross vehicle weight of more than 8,500 pounds.

HYDROCARBONS: A compound whose molecular composition consists of atoms of hydrogen and carbon only.

IDLE TEST: An emission inspection program which measures the exhaust emission from a motor vehicle operating at idle. (No motion of the rear wheels.) A vehicle with an automatic transmission may be in drive gear with brakes applied or in neutral gear.

INDEPENDENT CONTRACTOR: Any person, business firm, partnership or corporation with whom the state may enter into an agreement providing for the construction, equipment, maintenance, personnel, management and operation of official inspection stations.

INSPECTION AND MAINTENANCE PROGRAM: A program to reduce emissions from in-use vehicles through identifying vehicles that need emissions control related maintenance and requiring that maintenance be performed.

INSPECTION FEE: Annual payment for inspecting a vehicle.

INSPECTION STATION: A centralized facility for inspecting motor vehicles and pollution control devices for compliance with applicable regulations.

INSPECTOR: An individual who inspects motor vehicles and pollution control devices for compliance with applicable regulations.

LIFE CYCLE COSTS: Total of all costs incurred by a program during a predetermined period (life cycle).

LIGHT-DUTY VEHICLE: A motor vehicle designed for highway use of less than 8,501 pounds gross vehicle weight. Further distinctions are sometimes made between light-duty automobiles and light-duty trucks such as pickup trucks.

LOADED MODE TEST: An emission inspection program which measures the exhaust emissions from a motor vehicle operating under simulated road load on a chassis dynamometer.

MODEL YEAR OF ENGINE: The production period of new vehicle or new vehicle engines designated by the calendar year in which such period ends.

NMHC: Non-methane hydrocarbons.

OPERATING COSTS: Annual costs incurred during the operation of a program.

PRESCRIBED INSPECTION PROCEDURE: Approved procedure for identifying vehicles that need emissions control related maintenance.

START-UP COSTS: Initial expenditures for services necessary for laying the foundation of a program (e.g., initial labor costs, initial training, initial public information and program design).

TAMPERING: The illegal alteration, modification, or disconnection or emission control device or adjustments of manufacturer tuning specifications on motor vehicles for the purpose of controlling vehicle emissions.

VEHICLE EMISSIONS STANDARD: A specific emission limit allowed for the class of vehicles. The standard is normally expressed in terms of maximum allowable concentrations of pollutants (e.g., parts per million). However, a standard could also be expressed in terms of mass emissions per unit of time or distance traveled (e.g., grams per mile).